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HOMOPLASY AS A LAW OF LATENT OR POTENTIAL HOMOLOGY.

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My study of teeth in a great many phyla of Mammalia in past times has convinced me that there are fundamental predispositions to vary in certain directions; that the evolution of the teeth is marked out beforehand by hereditary influences which extend back hundreds of thousands of years. These predispositions are aroused under certain exciting causes and the progress of tooth development takes a certain form converting into actuality what has hitherto been potentiality.

Science, N.S., Vol. VI, No. 146 (Oct. 15, 1897), pp. 583-587.

IN previous communications, as shown in the above quotation, I have spoken of the "potential of similar variation," as covering cases of the independent evolution of identical structures in the teeth of different families of mammals, especially in relation to the homologous "antecrochet" and "crochet" folds in the teeth of horses, rhinoceroses, and we may now add, of titanotheres (Osborn, '94, p. 208). In the present communication I propose to treat somewhat more fully of the same phenomenon, as a special form of homology which has been clearly defined by Lankester in 1874 as *homoplasy*, but into which paleontology has brought the idea of "potential."

THE BROAD SIGNIFICANCE OF ANALOGY.

We are familiar with the classic distinction of analogous organs as having a similarity of function: *analogy* (Owen, '43, p. 374), "a part or organ in one animal which has the same function as another part or organ in a different animal"; Lankester ('70): "Any two organs having the same function are analogous, whether closely resembling each other in their structure and relation to other parts or not; and it is well to retain the word in that wide sense." Analogous organs may or may not be homologous. "Analogy" is therefore an extremely broad and comprehensive term, and it appears that we must include under it all cases of the similar evolution of organs either of common or of different origin due to similarity of function. For example, the "analogous variation" of Darwin, the "homoplasy" of Lankester in part at least, the "convergenz" of German writers, the "homomorphy" of Fürbringer, the "heterology," "parallels," and "parallelism" of Hyatt, of Cope ('68, also *Origin of the Fittest*, p. 96), of Scott, and of most American writers, are all illustrations of analogy and may be very misleading as to homology.

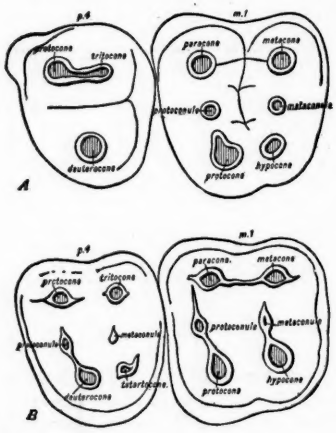


FIG. 1.— Fourth upper premolar and first molar of primitive ungulates. *A*, Euprotogonia; *B*, Hyracotherium. Not believed to be genetically related, yet exhibiting independent or homoplastic evolution of homologous cusps.

As Scott observed in 1896, "Parallelism[1] and convergence of development are much more general and important modes

[1] The term "parallelism" was employed by Cope in his essay of 1868 on the "Origin of Genera" (reprinted in the *Origin of the Fittest*) in two quite different senses: first, in relation to recapitulation in ontogeny, — "Those which accomplish less [stages] are *parallel* with the young of those which accomplish more [stages]; second, quite in the modern sense (*op. cit.*, pp. 96–104) of independently acquired resemblances in different groups. As employed by Scott in his essay

of evolution than is commonly supposed. By parallelism is meant the independent acquisition of similar structure in forms [*i.e.*, animals] which are themselves nearly related, and by convergence such acquisition in forms [*i.e.*, animals] which are not closely related, and thus in one or more respects come to be more nearly alike than were their ancestors."

The term "homoplasy" (Lankester) has been long used by the writer and others in a somewhat similar sense, but it is not equivalent either to "parallelism" or "convergence." As will be seen below, the fundamental idea is different, because homoplasy always involves homology, while parallelism and convergence may or may not involve homology.

ANALOGY IN EVOLUTION.

ANALOGY.

- *Analogous Variation* (Darwin). Similar congenital variation in more or less distantly related animals and plants.
- *Parallelism.* Independent similar development of related animals, plants, and organs.
- *Convergence.* Independent similar development of unrelated animals, bringing them apparently closer together.
- *Homoplasy* (Lankester) (?*Homomorphy*, Fürbringer). Independent similar development of homologous organs or regions giving rise to similar new parts.

In brief, analogy embraces similar changes due to similar adaptation in function both in homologous and in non-homologous organs, both in related and in unrelated animals.

THE LIMITED SIGNIFICANCE OF HOMOLOGY.

Owen ('**43**, p. 379), Lankester ('**70**), and Fürbringer have especially defined and elaborated the very ancient conception of homology, as employed by Oken, Geoffroy St. Hilaire, and Vicq d'Azyr: *homology* (Owen, '**43**), "the same organ in

"On the Mode of Evolution in the Mammalia" ('**91**, pp. 363–367), "parallelism" is used in a very broad sense as affecting the skeleton and teeth, on the principle "that identical modifications of structure, constituting evolution of types, have supervened on distinct lines of descent," as embracing not only single characters but whole series of them.

different animals under every variety of form and function"; *homogeny* (Lankester, '70): "Structures which are genetically related, in so far as they have a single representative in a common ancestor, may be called *homogenous*." E. B. Wilson ('95, pp. 101–124) has shown that the comparative anatomical test of homology is more reliable than the embryological. Gegenbaur ('98, pp. 23–25) has given a full presentation of the distinctions as the basis of comparative anatomy; in his recent great work ('98, p. 23) he presents the matter in terms which may be briefly analyzed with the usages of other authors, as follows:

I. HOMOLOGY, GENERAL: as of vertebræ and limbs.

1. HOMOTYPY: as of opposite limbs, eyes, kidneys, etc.
2. HOMODYNAMY: (in part the "general," in part the "serial," homology of Owen; the "meristic" homology of Bateson). Corresponding limbs, parts, segments (*e.g.*, the humerus and femur) on the same side of the body.
3. HOMONOMY: parts which are in the same transverse axis of the body, or on only one section of the longitudinal axis; *e.g.*, the rays of the fins of fishes, the single fingers and toes of the higher vertebrates are homonomous organs.

II. HOMOLOGY, SPECIAL: (the "homogeny" of Lankester).

1. COMPLETE HOMOLOGY of elements which have retained their relations unchanged, as of single bones from the Amphibia to the Mammalia.
2. INCOMPLETE HOMOLOGY, as of organs which have either gained new parts or lost certain of their parts.
   a. defective, as in comparison of fins of teleosts and of selachians.
   b. augmentative, as in the heart of cyclostomes and of the higher vertebrates.
   c. imitative, as where different vertebræ connect with the ilium and become sacral.

III. HOMOMORPHY (Fürbringer): from these homologies certain structures are to be distinguished as *homomorphic* which are more or less similar to each other but stand in no phylogenetic connection.[1]

Homomorphy comes nearest, as we understand it, to the "homoplasy" of Lankester, but the latter term has the priority of definition.

[1] Literally translated from Gegenbaur.

Distinction between Homogenous and Homoplastic Organs.

In the strictest sense, special or genetic homology, the "homogeny" of Lankester, is the only absolute homology. For example, in all four-limbed vertebrates, or Tetrapoda (Credner), the first and second phalanges of the tibial digit or hallux are homogenous; the earliest tetrapods had such phalanges, so far as we can judge from both paleontology and embryology, and all others are derivatives.

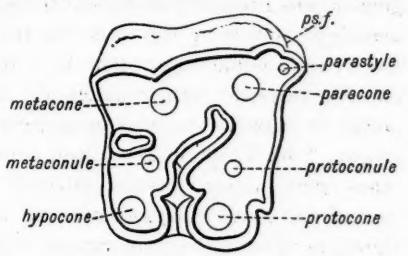


Fig. 2.— Ideal embryonic ground plan of rhinoceros molar, showing relation of primitive cusps to the folds and crests.

But suppose we should discover that these two phalanges had originated independently in several different classes of vertebrates, and were not derivatives; should they then be considered analogous or homologous? "Again," says Lankester ('70), "it may perhaps be admitted that the common ancestors of the Osseous Fishes and Mammalia had a skull of decidedly undifferentiated character, with a much less amount of differentiation than is observed in the skulls of either of these groups. It is only in so far as they have parts represented in the common ancestor that we can trace *homogeny* in these groups; and yet the *homology* of a vast number of bones in the skull of the two is discussed and pointed out." Suppose, accordingly, that in the formation of dermal roofing bones in different orders of fishes a pair of bones corresponding in position to the parietals should arise

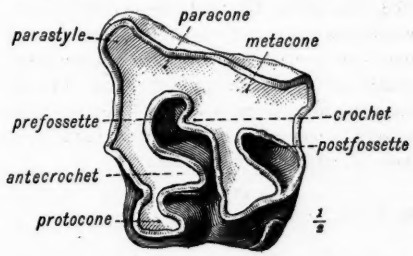


Fig. 3.— Molar tooth of an Upper Miocene rhinoceros (Teleoceras), showing origin of secondary folds.

independently, or that in the evolution of the teeth cusps should arise independently having the same form and position, — what criterion should be applied? All such structures are habitually regarded as homologous, yet it is apparent that they are not derivatives of each other and therefore not homogenous or homologous in the strictest sense.

Such cases of independent evolution of apparently homologous organs I recently proposed[1] to signify as *potential*, or *latent homology*, borrowing the term "latent" from Galton as indicative of a germinal rather than of a patent or adult character, and the physical term "potential" as expressing the innate power or capacity to develop a certain organ. But my colleague, Prof. Edmund B. Wilson, pointed out to me that such cases were almost exactly covered by the *original definition* of the word "homoplasy" by Lankester ('70, p. 42), as shown in the subjoined quotations from his essay:

> When identical or nearly similar forces, or environments, act on two or more parts of an organism which are exactly or nearly alike, the resulting *modifications*[2] of the various parts will be exactly or nearly alike. Further, if, instead of similar parts in the same organism, we suppose the same forces to act on parts in two organisms, which parts are exactly or nearly alike and sometimes homogenetic, the resulting correspondences called forth in the several parts in the two organisms will be nearly or exactly alike. I propose to call this kind of agreement *homoplastic* or *homoplasy*.[3] . . . What is put forward here is this: that under the term "homology," belonging to another philosophy, evolutionists have described and do describe two kinds of agreement, — the one, now proposed to be called "homogeny," depending simply on the inheritance of a common part; the other, proposed to be called "homoplasy," depending on a common action of evoking causes or moulding environment on such homogenous parts, or on parts which for other reasons offer a likeness of material to begin with.

$$\text{Homology thus includes} \begin{cases} \text{Homoplasy.} \\ \text{Homogeny.} \end{cases}$$

It follows that subsequent writers, including myself, have misused the term "homoplasy," confusing it with "parallelism"

[1] In a communication before the National Academy of Science, Nov. 13, 1901.

[2] Italics are mine.

[3] At this time Lankester accepted Herbert Spencer's Lamarckian views. Subsequently he abandoned the mechanical inheritance theory for the pure natural selection theory.

and "convergence," which, as we have seen, may affect absolutely non-homologous structures. *Homoplasy should be confined to structures in which there is an element of homology.*

Independently of Lankester (that is, not familiar with his paper) I had therefore reached a similar conclusion through years of observation in paleontology. I would now like to expand an idea which he also lightly suggested in 1870 in the words, "*or on parts which for other reasons show a likeness of material to begin with.*"

The Law of Homoplasy as in Part Identical with Definite or Determinate Variation.

As observed in the evolution of the teeth especially, homoplasy appears to be of very great importance, not on the technical grounds of uniformity in nomenclature, but because it seems to coincide with the principle of definite or determinate evolution, a principle which may be of wider application.[1]

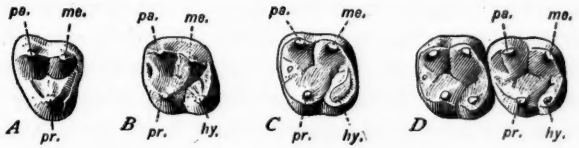


Fig. 4.—Superior molars of primates, Anaptomorphus to Homo, showing independent or homoplastic origin of the hypocone, *hy*, from the cingulum.

From the time of the "Origin of Species" it has been admitted that evolution, so far as it depends upon variation, is not in every possible direction, but is limited to certain changes, the expression of certain hereditary or constitutional causes which we do not in the least understand. The evolution of the teeth of mammals enabled me in 1889 to give many concrete illustrations of this principle and to show that variation is hardly the proper term to apply to rudiments which do not arise in a variable but in a fixed manner.

[1] See especially the correspondence of Darwin and Asa Gray; also Osborn, The Palæontological Evidence for the Transmission of Acquired Characters, *Nature*, Jan. 9, 1890; the Orthogenesis and Orthoplasy of Eimer, Lloyd Morgan and Baldwin; Baldwin's *Dictionary of Philosophy and Psychology*, vol. i, p. 243.

It appears that von Waagen suggested the term "mutation" for immeasurable variations somewhat similar to these. Scott in 1891 ('**91**, p. 388) pursued the idea further in the following striking passage: "These facts at least suggest the possibility that individual variations are not incipient species, but that the

FIG. 5. — Superior molars of primates. *A*, Adapis; *B*, Hyopsodus; *C*, Notharctus. Showing homoplastic cusps, *hy*, *ml*, *ps*, *ms*, *mts*.

causes of transformation lie deeper, and act with more or less uniformity upon large numbers of individuals. It may, perhaps, be the outcome of future investigations, that while variations are generally due to the union of changing hereditary tendencies, mutations are the effect of dynamical agencies operating long in a uniform way, and the results controlled by natural selection. While this *may* be true, a great many facts must be gathered in its support, before it can be regarded as more than a suggestion." Scott subsequently, in his article "Variations and Mutations," expanded this idea: "Bateson's results, as compared with those of paleontology, confirm this distinction in many significant ways and emphasize strongly the difference between variation and that steady advance along definite lines which Waagen called mutation." This paper in turn is said to have influenced de Vries's recent work, *Die Mutationstheorie.*

It is a singular coincidence that the human teeth were selected by both Empedocles and Aristotle to test the "survival of the fittest" *versus* the purposive or teleological theory of evolution. I pointed out in the papers above referred to (Osborn, '**89**, pp. 561–566; '**90**) the significant fact that new cusps of the molar teeth do not appear at random, but at certain definite points; that they are at first so minute that

they can barely be perceived, so that it is difficult to theoretically assign them a survival value in the struggle for existence; that the mechanical or Lamarckian explanation is the only one which can be offered[1]; I laid the chief stress, however, not upon the mechanical explanation, but upon definite or determinate origin, and this has been confirmed by the subsequent study of thousands of teeth in different families of mammals. The still more significant fact that this definite and determinate evolution was proceeding independently in a great many different families of mammals did not at the time impress itself so strongly upon my mind.

If molar teeth are found independently evolving in exactly similar ways in such remote parts of the world as Switzerland, Wyoming, and Patagonia, it is obvious that the process is not governed by chance but represents the operation of some similar or uniform law deduced from the four following considerations:

Firstly, the teeth differ from all the other tissues and organs of the body in being preformed, beneath the gum.[2] Unlike all other organs they are not modified, improved, or rendered more adaptive by use; on the contrary, after the first stage of wear,

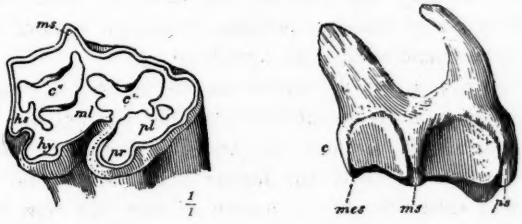


FIG. 6. — Superior molar of Merychippus, showing styles *ps*, *ms*, *mts*, and conules *pl*, *ml*, homoplastic with those of the wholly unrelated primate molar, Fig. 5, *C*.

the longer they are used the more useless and less adaptive they become. Thus, new structures in the teeth do not first appear as *modifications* (as distinguished from congenital

[1] Ryder and Cope confidently advanced the mechanical explanation; it is not without grave difficulties, owing to the lack of an heredity theory.

[2] The importance of this fact was first pointed out to me by Prof. E. B. Poulton of Oxford.

variations) in course of life, as is so often if not invariably the case with new structures in the skeleton. New cusps, folds, crests, and styles are invariably congenital. Thus, of all organs of the body the teeth most exclusively and purely represent the current of stirp, germinal, or constitutional evolution.

Secondly, the teeth are, nevertheless, among the most progressive organs in the body. Whereas the adaptation of the skeleton, among the mammals at least, is by a constant loss or numerical reduction of parts, the adaptation of the teeth is by a constant addition and modeling of parts (Osborn, '88, pp. 1067–1079).

Thirdly, according to the present paleontological evidence many of the different families and orders of mammals diverged from each other at a time when they possessed three cusps on the upper molar teeth and from three to five cusps on the lower molar teeth. This being the case, only the cusps comparable in different orders of mammals with these original three upper and five lower cusps are derivatives or homogenous.

Fourthly, it follows that the new cusps of the teeth furnish an example of homoplasy independent of the individual modification.

Thus, we may say that in the teeth at least *homoplasy involves a law of latent or potential homology*, without professing to understand what is its significance.

We should, *a priori*, expect that if additional cusps were added independently in different families and orders of mammals in different parts of the world, under highly different conditions, the teeth of the higher Mammalia would present very great diversity. As a matter of fact, the new cusps in different families are absolutely uniform up to a certain limit.[1] In the twenty-three orders of placentals and in the seven marsupial families, many of which are adaptively equivalent to orders, the independently developed fourth to eleventh cusps of the upper molars, if so many are developed, are uniform and may be termed homologous; the eight cusps and folds succeeding the original homogenous three arising, if at all,

[1] The excess of this limit is in multituberculism, or polybunodonty, where cuspules are indefinitely multiplied.

at similar points and presenting a latent homology or homoplasy. The record in the upper molar teeth stands thus :

HOMOLOGY.

HOMOGENY	HOMOPLASY
Primitive three cusps common to all mammals.	Cusps or folds which are or may be independently developed in different orders.
Protocone	Hypocone
Paracone	Metaconule
Metacone	Protoconule
—	Parastyle
—	Mesostyle
—	Metastyle
—	Protostyle
—	Hypostyle

This expresses the comparison of mammals as a whole. Within many of the orders, such as the Perissodactyla, which arise from six cusped ancestors, the homology is different.

HOMOLOGY.

HOMOGENY	HOMOPLASY
Protocone	Parastyle
Paracone	Mesostyle
Metacone	Crista
Hypocone	Crochet
Protoconule	Antecrochet, etc.
Metaconule	—

The elements to which these terms are applied are best exemplified in the molar teeth of some of the primitive horses (Fig. 6).

The teeth are by no means the only structures which evolve under this principle, the skull, vertebral column, and limbs also evolving under it more or less completely; but the teeth afford a singularly beautiful illustration of it because they exclude individual modification.

The chief object of this communication is to enforce the recognition of homoplasy as something which must be accounted for. These homoplastic cusps do not arise from selection out of fortuitous variations, because they develop directly and are not picked from a number of alternates. Neither does it appear that the mechanical-inheritance theory, if granted, would produce such a remarkable uniformity of result. We are forced to the conclusion that in the original tritubercular constitution of the teeth there is some principle which unifies the subsequent variation and evolution up to a certain point. Herein lies the appropriateness of Lankester's phrase, "a likeness of material to begin with."

Philosophically, predeterminate variation and evolution brings us upon dangerous ground. If all that is evolved in the Tertiary molar tooth is included in a latent or potential form, in the Cretaceous molar tooth we are nearing the *emboîtement* hypothesis of Bonnet or the archetype of Oken and Owen. Embryologists have recently gotten into the same dilemma, and my colleague, Wilson, has proposed to drop the idea "homology" altogether and substitute the idea "equivalent." In the present case, however, I think we have to deal with homology or, more strictly, with a *principle intermediate between homology and analogy*.

In a paper recently read before the American Morphological Society (December, 1901), this author has urged the necessity of adhering as closely as possible to the historical standard in the embryological study of homology, and of avoiding the use of the term "homology" when this standard is not available. He therefore suggests for descriptive purposes the use of the non-committal terms "equivalent" and "homoblastic," the former being applied to embryonic structures of like fate (*i.e.*, giving rise to homologous parts), the latter to those of like embryonic origin. The only decisive test of the homology is historic community of derivation (*i.e.*, homogeny).

BIBLIOGRAPHY.

'68 COPE, E. D. On the Origin of Genera. *Proc. Acad. Nat. Sci. Phila.* October, 1868.

'87 COPE, E. D. The Origin of the Fittest. 8vo. New York.

'98 GEGENBAUR, CARL. Vergleichende Anatomie der Wirbelthiere. 8vo. Leipzig, 1898.

'70 LANKESTER, E. R. On the Use of the Term "Homology" in Modern Zoölogy and the Distinction between Homogenetic and Homoplastic Agreements. *Ann. Mag. Nat. Hist.* Ser. 4, vol. iv, pp. 34–43.

'89 NEUMAYR, M. Die Stämme des Thierreiches. 4to. Pp. 60–61. Vienna, 1889.

'88 OSBORN, HENRY F. The Evolution of Mammalian Molars to and from the Tritubercular Type. *Amer. Nat.* Vol. xxii (December, 1888), pp. 1067–1079.

'89 OSBORN, HENRY F. The Palæontological Evidence for the Transmission of Acquired Characters. *Amer. Nat.* Vol. xxiii (1889), pp. 561–566.

'90 OSBORN, HENRY F. Evolution and Heredity. *Biological Lectures, 1890, Marine Biological Laboratory, Woods Hole.*

'94 OSBORN, HENRY F. The Rise of the Mammalia in North America. *Proc. Amer. Assoc. Adv. Sci.* Vol. xlii (1893), pp. 187–227.

'43 OWEN, RICHARD. Lectures on the Comparative Anatomy and Physiology of the Invertebrate Animals, delivered at the Royal College of Surgeons in 1843. 8vo. London, 1843.

'91 SCOTT, W. B. On Some of the Factors in the Evolution of the Mammalia. On the Osteology of Mesohippus and Leptomeryx, with Observations on the Modes and Factors of Evolution in the Mammalia. *Journ. of Morph.* Vol. v, No. 3 (1891), pp. 379–402.

'94 SCOTT, W. B. On Variations and Mutations. *Amer. Journ. Sci.* Vol. xlviii (November, 1894), pp. 355–374.

'96 SCOTT, W. B. Palæontology as a Morphological Discipline. *Biological Lectures, 1895, Marine Biological Laboratory, Woods Hole.* Pp. 43–61. Boston, 1896.

'01 DE VRIES, HUGO. Die Mutationstheorie. Versuche und Beobachtungen über die Entstehung von Arten im Pflanzenreich. 8vo. Leipzig, 1902.

'95 WILSON, E. B. The Embryological Criterion of Homology. *Biological Lectures, 1895, Marine Biological Laboratory, Woods Hole.* Pp. 101–124. Boston, 1895.

NEW INSTANCES OF COMPLETE DIVISION OF THE MALAR BONE, WITH NOTES ON INCOMPLETE DIVISION.

ALEŠ HRDLIČKA.

THE malar bone in man, and also among lower mammals, is found occasionally to present a partial or a complete division.

The complete malar divisions are in general rare; the incomplete ones are rare in most of the species of the lower mammals, but are quite common in man. Both varieties of the divisions occur with unequal frequency in the different races of man, and, seemingly, even in different localities in the same people.

The first case of a complete malar division in man was described in 1779 by Ed. Sandifort.[1] Since then the anomaly has been observed among most of the principal branches of the whites and also among the Japanese, Aïnos, Chinese, Buriats, Bashkirs, Burmans, natives of the Malay Archipelago and of the Philippine Islands. The most important contributions to the literature of the subject are those by Breschet,[2] Wenzel Gruber,[3] and Virchow[4]; other authors who occupied themselves with malar divisions are Amadei,[5] Flesch,[6] Riccardi,[7]

[1] *Observat. Anat. Pathol.* Lugd., Batav., 1779. Vol. iii, 8, p. 113. Cit. Gruber.

[2] Recherches sur différentes pièces osseuses du squelette de l'homme et des animaux vertébrés, *Ann. d. Sci. Natur.*, Sér. 3, tome i, p. 25. Paris, 1844.

[3] Monographie über das zweigetheilte Jochbein, etc., Wien, 1873; five additional publications on the subject in *Arch. f. Anat. u. Phys.*, 1873, p. 208; 1875, p. 194; 1876, p. 230; and in *Arch. f. pathol. Anat. u. Phys.*, 1877, Bd. lxix, p. 382; and 1879, Bd. lxxvii, p. 113.

[4] Über die ethnologische Bedeutung des os malare bipartitum, *Monatsberichte d. k. preuss. Akad. d. Wiss.* Berlin, 1882, p. 230.

[5] *Arch. p. l' antropol. e l' etnolog.*, 1877, p. 11.

[6] Über das zweigetheilte Jochbein, *Verhandl. d. phys.-med. Ges. in Würzburg*, 1877, pp. 51, 52.

[7] Suture anomale dell' osso malare, *Arch. p. l' antropol. e l' etnolog.*, tomo viii (1878), pp. 1 *et seq.*

Hilgendorf,[8] Tarenetzkij,[9] Calori,[10] Matiegka,[11] etc. In other mammals cases of complete malar division have thus far been found in two *Cercopitheci sabæi* (Laurillard,[12] Breschet[2]); in four *Mycetes seniculi* (Laurillard, Breschet); in one *Mycetes niger* (Breschet); in an orang (Flesch[6]); in a hippopotamus (Breschet); and in a *Phascolomys wombatus* (Gruber[3]).

The complete malar divisions present some variety. In a very large majority of the cases, both in man and the lower mammals, the malar was found divided into two portions by a suture running antero-posteriorly from the malo-maxillary to the zygomatic articulation. In the orang described by Flesch the posterior extremity of the anomalous division terminated on the temporal border of the malar bone, a short distance anterior to the upper end of the zygomatic suture. In two of Calori's cases the posterior termination of the anomalous suture was situated respectively at the base and above the middle of the ascending portion of the temporal border. The second of these cases shows much similarity with one I have at hand, in which the malar division is due to fracture (*v.* the end of this paper).

Testut reports a case[13] in which the division ran in a curve from the ascending portion of the orbital border to the middle of the malo-maxillary suture. Spix,[14] Breschet,[2] Riccardi,[7] and Ruggeri,[15] finally, observed a division of the malar into three portions, the location of which differed in each instance.

Of incomplete malar divisions there have been described thus far only horizontal ones in which the suture connects with either the zygomatic or the malo-maxillary suture.

[8] *Arch. f. patholog. Anat. und Phys.*, Bd. lxx (1879), pp. 113 *et seq.*

[9] Beiträge zur Craniologie der Aïnos und Sachalin, *Mém. de l'Acad. Imp. Sci. de St. Pétersbourg*, Sér. 7, tome xxxvii (1890), p. 39.

[10] Su le anomalie dell' osso zigomatico, etc., *Mem. d. R. Accad. d. Sci. dell' Istit. d. Bologna*, Ser. 5, tomo iii (1893), p. 415.

[11] Prvni Lebka z Čech s "Os Malare Bipartitum," *Věstnik Král. České Společ. Náuk*, vol. xxviii, pp. 1–24. Prague, 1899. Also in German.

[12] In Cuvier's *Leç. d'Anat. Comparée*, 2d ed., tome ii (Paris, 1837), pp. 385, 386. Cit. Gruber.

[13] *Traité d'Anatomie Humaine*, tome i, p. 174. Paris, 1889.

[14] *Cephalogenesis s. capitis ossei structura, formatio et significatio* (Monachi, 1815), p. 13. Cit. Gruber.

[15] Un osso zigomatico tripartito, *Rivista Sperim. di Treniatria*, tomo xxiii (1897), p. 460; refer. *Centralbl. f. Anthropol.*, Bd. iii (1898), p. 20. Cit. Matiegka.

The presence of a malar division is generally held to signify a non-fusion of the original centers from which the bone developed. It is not yet definitely settled whether there are usually two or three of these centers. According to Breschet the malar bone develops in the majority of cases from one, in a smaller number of instances from two, and occasionally from three centers of ossification. Gruber was of a similar opinion. Rambauld and Renault, on the other hand, advanced the theory that the malar develops always from three points of ossification. In the words of these authors (*Origine et développment des os* (Paris, 1864), pp. 161, 162, Atlas, Pl. XIII, Figs. 4, 5), "nous l'avons (l'os malaire) toujours vu s'ossifier par un seul centre, mais composé de trois points." "Ces points . . . apparaissent de très bonne heure et se réunissent très-vite." "Vers le milieu, et plus souvent à la fin du second mois, l'os malaire est composé de trois points." The subject is much in need of further embryological investigation.

Nothing is known as to the immediate causes of the anomaly and but little as to its signification.

The meaning and importance of the incomplete divisions will be considered later.

New Testament of Complete Malar Division.

The new cases of complete malar division which came under my observation comprise one instance of the anomaly in a white adult woman, one in an adult male Peruvian (prehistoric), a bilateral division in an orang and in a Lagothrix, and a unilateral one in a Cercopithecus, a Mycetes, and a bear. In detail, these cases are as follows:

Fig. 1

Case 1 (Fig. 1). — The first specimen consists of a part of the face, including the right malar, of a white adult female, found by me among the unidentified bones in Professor Huntington's osteological collection in the College of Physicians and Surgeons (Medical Department, Columbia University), New York City.

The malar bone shows remnants of an anomalous division, which separated the frontal process from the body of the bone.

The division runs in the line of the posterior or horizontal position of the temporal border of the malar and consists of a row of small, irregular perforations, with a larger, round foramen in the middle. It is plain, on both the anterior and posterior surfaces of the bone, that the line of openings is the remnant of a former complete separation of the frontal process.

There are no signs of injury. The part of the face with the left malar has not been recovered. The right malar shows no further abnormality.

The malar division in this specimen is analogous with the superior of the two divisions in the case described by Riccardi, and is considered by Matiegka, whom I informed of the case, to represent a non-union of the superior of three centers from which the bone developed.

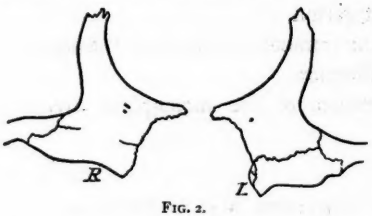


FIG. 2.

Case 2 (Fig. 2). *Malar Division in a Peruvian.* — This is the first instance of a complete malar division found among aboriginal Americans. It is the only skull with a complete division that I found among 492 old-Peruvian and over 2000 other Indian crania from various localities. The specimen is one of the Bandelier collection, in the American Museum of Natural History, New York City.

The skull is that of a male of between forty and fifty years of age. It is of a moderate size, and shows nothing extraordinary except a moderate artificial frontal compression and a persistence of the metopic suture.

The left malar presents a complete and patent, horizontal, serrated suture, which divides it into a narrow lower, and large upper, portion. The right malar shows in a similar location a 0.5 cm. long, straight, anterior, and a 0.7 cm. long, slightly serrated, posterior, incisure.

The two malars differ considerably in size, the left one being higher, but narrower, than the right one.

	Left.	Right.
Highest point of fronto-malar suture vertically downward to the anomalous suture,	4.2 cm.	——
Highest point of fronto-malar suture vertically downward to lower edge of the malar,	5.2 cm.	4.4 cm.
A line between the most superior point of the malo-maxillary and the zygomatic suture,	3.7 cm.	3.9 cm.
A line between the most inferior point of the malo-maxillary and the zygomatic suture,	2.7 cm.	3.2 cm.

This excess in height and deficiency in breadth of the fully divided malar when compared to its mate is in full accordance with previous observations on this point. A relative narrowness of the inferior of the two portions of the divided malar is also more the rule than the exception.

The incisures in the right malar have apparently influenced the growth of that bone but little. The evidence of the measurements is against their equivalence with the complete division on the right. If these incisures are remnants of a complete division, the measurements indicate an early union of the middle portion of the malar.

The presence of the frontal division has apparently no relation to that in the malar bone. A persistent metopic suture is present in 97 of the 492 Peruvians, without there being another case of a complete malar division; there is also in these skulls no excess of malar incisures.

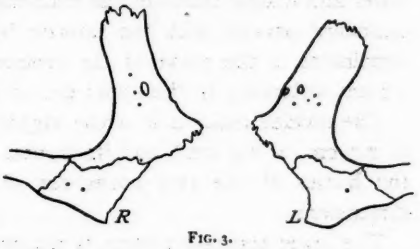


Fig. 3.

Case 3 (Fig. 3). *A Bilateral Complete Malar Division in an Orang.* — The skull is that of a young orang and is a part of a mounted skeleton in Professor Huntington's museum in the College of Physicians and Surgeons, New York City. Besides the malar divisions the specimen shows nothing unusual.

The malar sutures are in every way much alike on the two sides. They run each with a moderate double curve from near

the middle of the malo-maxillary to very near the superior termination of the zygomatic suture. Both divisions are slightly serrated.

The right malar bone is slightly higher than the left one, but the frontal process and to a less extent the body of this latter is broader.

The situation of the malar sutures in this case is similar to that in the orang described by Flesch; the posterior termination of the division in Flesch's case lay, however, still somewhat higher, terminating on the temporal border of the malar, slightly anterior to the zygomatic suture.

Case 4 (Fig. 4). *A Unilateral Complete Malar Division in a Cercopithecus callitrichus.* — Among the forty skulls of Cercopitheci in the zoölogical collection of the American Museum of Natural History, New York City, there is one with a complete and one with a partial malar division.

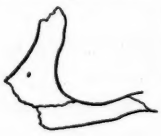


FIG. 4.

The skull with the complete division belongs to an adult female, *C. callitrichus* (No. 13,923), and shows besides the malar also a bilateral parietal division.

The malar division is found on the left only; there is no trace of a similar anomaly on the right side.

The malar suture begins anteriorly at a point between the lower and middle thirds of the malo-maxillary articulation, runs backward parallel with the inferior border of the malar, and terminates in the curve of the temporal border of the bone, 0.8 cm. anteriorly to the upper end of the zygomatic suture.

The divided malar is in whole higher than the undivided one (l. 2.9 cm., r. 2.4 cm.), and its frontal process is broader; but the bodies of the two bones are of very nearly the same dimensions.

The lower separate portion is relatively narrow.

Neither in this nor in any of the preceding cases is there an extension of any process of bone from the zygoma to the maxillary.

The case of a partial malar division in a Cercopithecus (Fig. 5) may be conveniently described in this connection. The skull showing this anomaly is that of an adult animal of unknown

sex and variety. It is free from other abnormalities. The division occurs in the right malar bone. It begins distally in the deepest portion of the curve of the temporal border of the bone, is somewhat curved, well serrated, and extends forward to the middle of the body of the bone. It is equally pronounced on the anterior and posterior surface of the malar. The divided bone is externally very slightly higher than the other malar, and its body is slightly narrower.

FIG. 5.

Case 5 (Fig. 6). — The skull of an adolescent male *Lagothrix humboldti* (specimen No. 6333, American Museum of Natural History, New York) shows a bilateral, antero-posterior, complete malar division. Anteriorly the division begins on each side slightly below the middle third of the maxillary border of the bone and from this point runs horizontally backward, to terminate on the temporal border of the malar. The posterior termination of the division reaches to within one millimeter of the superior portion of the zygomatic suture on the left and to within two and a half millimeters of the same on the right side. Both the anomalous sutures are serrated. They show both much better dorsally than ventrally. In this specimen there is on each side but a slightly incomplete temporo-maxillary arc. The large malar foramina (regular in these monkeys) are situated well above the divisions. The two malars are very nearly of equal size, except anteriorly, where the right bone is slightly higher.

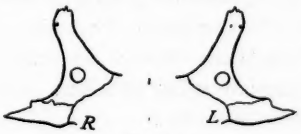


FIG. 6.

The skull shows no other anomalies, nor anything pathological. In three other skulls of monkeys of the same variety the malars are normal.

Case 6 (Fig. 7). — Among twelve skulls of Mycetes, in the American Museum of Natural History, there is one (No. 14,169) which shows a complete unilateral malar division.

The skull with a complete division is one of an adolescent male *M. alouata*, and is otherwise in every respect normal.

The division affects the left malar. It begins anteriorly slightly above the lower third of the maxillary border of the bone and runs, with some serration, backward, very nearly parallel with the inferior border of the malar, to the zygomatic suture near its superior termination. Ventrally the division is covered by a broad temporo-maxillary arc.

FIG. 7.

The right malar is normal. It is both lower and narrower than the left bone, and even the zygomatic arch is lower on the right.

MEASURES.

	LEFT.	RIGHT.
Height along the maxillary border,	2.0 cm.	1.85 cm.
Width at middle (width minimum),	0.6 cm.	0.55 cm.
Height of temporal process vertically, from the superior end of the zygomatic suture,	0.8 cm.	0.65 cm.

In a skull of Mycetes, in the same collection, there is in each temporal border of the malar, slightly anterior to the zygomatic suture, a short incisure, directed forward.

Besides those already mentioned I have examined, for malar divisions, the skulls of 6 Lemurs, 5 Nictipitheci, 31 Cebi, 10 Ateles, 1 *Silenus vetur*, 16 Cercocebi, 1 Senmopithecus, 54 Macaques, 4 Mormons, 1 Innuus, 2 Cynopitheci, and 16 Cynocephali, — all in the collection in the American Museum of Natural History. Among these specimens there is none with complete and only a few with incomplete malar divisions. Of these latter only the following one deserves to be mentioned in this place.

FIG. 8.

Cynocephalus olivaceus (No. 10,747 ; Fig. 8). — The left malar shows a faint and only dorsally visible, incomplete, serrated suture, running from a point a very little above the lower third of the maxillary border of the bone to the malar foramen. The length of the suture is 1.1 cm. The right malar shows traces of a similar division. The two malars are almost exactly equal.

This case differs from any thus far on record. The exact nature of the division is uncertain.

Case 7, Unilateral Malar Division in a Bear. (No. 4282, American Museum of Natural History; Fig. 9). — The division affects the left malar of a young American black bear (incisors and canines not yet replaced by teeth of the second dentition).

Dorsally only the superior third of the division is open, the other portion of it being secluded but still traceable; ventrally the anomalous suture is patent in its entirety.

The division begins anteriorly considerably below the middle of the malo-maxillary articulation and runs in almost a straight

FIG. 9.

direction upward and slightly backward, to the base of the frontal process. The suture shows a slight serration.

The frontal process of both the malars is partly detached. The right malar shows a small anterior incisure in a location corresponding to the antero-inferior terminus of the division on the left. Finally, there are on the left one small bone and two larger, oblong ones, and on the right one large, oblong osside, intercalated between the antero-inferior two-thirds of the malar and the superior maxilla.[16]

The two malars show but little difference in size.

The above specimen is one of twenty young adolescent and young adult skulls of bears of the same variety preserved in the American Museum of Natural History. No other of these skulls presents a complete malar division similar to that in No. 4282; several of the specimens, however, show an anterior malar incisure, visible on the internal surface of the bone. Besides this almost all the specimens present more or less of a separation of the frontal process of the malar. In four of the

[16] A similar bone has been found in man by Gruber (*Arch. f. Anat., Physiol.*, etc. (1873), p. 195, Pl. V, Fig. 1). See also Breschet.

skulls the separation of the process is complete, in two bilaterally and in one on one side. The following figure shows one of these instances; in this case there is not only a complete separation of the frontal process, but also a superior incisure, running in a similar direction to the anomalous suture in the young bear (No. 4282; Fig. 10).

Separations of the frontal process, such as the one just pictured, have been observed in the seal and walrus (Meckel, Pander, d'Alton, Hallman, Köstlin, cit. Gruber; the condition is present in a number of young seals in the collection in the American Museum of Natural History); they remind one of the superior division of the malar in Riccardi's case and the one similarly situated in the first case reported in this paper.

FIG. 10.

The division of the body of the malar bone is, as shown in the bear (No. 4282), independent of the separation of the frontal process. This latter appears in the bears as an epiphysis of a comparatively late formation.

It is interesting to note that the posterior termination of the malar suture, situated somewhat higher in the orangs, is placed still higher, relatively, in most of the specimens in lower monkeys and other mammals. This condition is very marked in the Cercopithecus and especially in the young bear. The cause of this lies, it seems to me, not so much in a different situation of the centers from which the malar develops, as in the different tilting of the bone, and in the differences in the temporal process, in man and the mentioned animals. The human malar bone is less tilted than that in bears, and its temporal process is considerably shorter and relatively broader than that of apes, monkeys, and bears, as well as other mammals.

PARTIAL MALAR DIVISION.

The anterior and particularly the posterior portion of the malar shows occasionally a partial division. These divisions occur mostly in the form of lineal incisures, but occasionally also as serrated sutures. They differ much in length, in some

cases not exceeding one or two millimeters, in others extending to near the middle of the malar. In man they run as a rule in an antero-posterior direction, beginning distally from either the zygomatic or the malo-maxillary suture.

The posterior divisions are in the average more pronounced and much more frequent than the anterior ones. An anterior and a posterior partial division may coexist in the same bone, and there is a tendency, though there are exceptions, to similar divisions on the two malars.

There is a considerable difference in the frequency of these partial malar divisions in different peoples. They are found in the adults of both sexes, but grow more rare as age advances; they are, according to my data, somewhat more frequent in early than in adult life.

These malar incisures are well known, but their meaning is still somewhat doubtful. Gruber, who was the first to give these divisions close attention, considered them as morphologically distinct from the complete separations. In the words of this author (*Virch. Arch.*, Bd. LVII, 1879, p. 117), "*os zygomaticum bipartitum* is a term applied only to that malar bone which is fully divided into two portions and persists thus divided after the second month of the fœtal life, as well as after birth; or to that malar, which was originally fully divided, but in which the anomalous suture became later (in adult life), in consequence of synostosis, more or less occluded." "When [*ibid.*] in a fœtal malar bone, through a hindrance in development (Bildungshemmung), the streaks between the orbital and maxillo-zygomatic portion of the bone do not on one or both sides ossify, and this defect of ossification persists, in the form of an incisure, into advanced age, leaving thus a sort of a *sutura mendosa*, in that case one evidently cannot speak of a divided malar."

This apparently clear and rational theory was three years later opposed by Virchow.[1] This author expresses himself (p. 251) as "inclined to recognize the majority of all malar incisures, particularly the posterior ones, as real remnants of an old transverse malar suture"; but (p. 252) "the interpretation of a posterior incisure will be the more doubtful, the higher the situation of the incisure."

Both Gruber's and Virchow's opinions gained adherents, and in the absence of decisive embryological investigation the matter is still unsettled.

The significance of the partial malar divisions can be actually demonstrated only by studies on the embryo. Nevertheless, the examination of older subjects brings out a few points from which, it seems to me, it is possible to draw a few deductions having a bearing on the nature of these divisions.

Such points are the size of the incisures, their somewhat greater frequency in childhood than in adult life, and the lack of correspondence in frequency between the incomplete and complete divisions in childhood in general or in the adults of different ethnic groups.

All the points mentioned speak *against an exact equivalence* of the partial and complete malar divisions and for Gruber's theory. Were all or a majority of the incisures remnants of formerly complete separations of the malar, it is reasonable to suppose that we should, even if rarely, meet with a remnant of the separation that would extend over more than a half of the bone; and it would be logical to expect a greater frequency of complete divisions in early than in later life and in those tribes or races in whom the incisures are more common than in others. As these conditions *are not realized* we must search for another explanation for the incisures. This explanation can be found, as already pointed out by Gruber, in the analogies of the development of the malar with other cranial bones, particularly the occipital, or the parietal.

The parietal bone will, I think, serve the demonstration even better than the occipital. The bone develops, as was shown by Toldt and Ranke, from two superimposed centers of ossification, — a very similar process to that which undoubtedly takes place in the body of the malar, though this bone may possibly develop from more than two original points. The two centers of the parietal have but a very brief separate existence. They grow in all directions and very soon coalesce. Their union takes place at their reciprocally most advanced portions, in the middle, the parts anterior and posterior to this point of fusion remaining separated by a more or less V-shaped space or fissure.

This fissure, as the bone grows, gradually closes at its proximal extremity, but becomes extended, by the new bone, at its distal end. The result of this is that even as late as at the birth of the human fœtus the parietal bone shows a more or less marked posterior, and rarely also an anterior, partial division, exactly analogous with, it seems to me, though almost generally less persistent than, the malar incisures. The parietal division may persist even up to adult life and then the analogy between the same and a malar incisure is still closer. The difference between this form and a complete division (or a remnant of such) in either the parietal or the malar is that in the simple incisure and fissure we have before us only a *retardation* of the union of the distal portions of the original segments of the bone, while in the complete division (or its remnant) we are confronted with a case of a complete non-union and *separate development* of these segments. The two effects may be produced, and probably are produced in such a case as that in the Peruvian skull with a complete malar division on one and two incomplete ones on the other side, by different degrees of the same cause ; nevertheless they cannot be considered identical. The cause which induces a separate development of all or some of the centers of ossification of a bone must be potent and be present extremely early ; a persistence of a fissure might be due to a weaker cause of the same nature, but possibly also to later causes of differing kind. The complete divisions deserve fully the term "anomalies," or "atypical formations," while the partial divisions come more under the category of developmental defects or retardations.

The partial malar divisions are not attended by similar conditions in other bones of the skull. They also do not seem to stand in any relation with the metopic division ; specimens with the frontal suture in my Peruvian series have, upon an additional inspection, shown no greater percentage of malar incisures than other skulls in the same collection.

There is nothing in the appearance of the partial divisions, except, perhaps, their size, which would allow us to differentiate them from *remnants* of complete malar sutures. Should a division extending beyond the middle of the bone be found, it

would then be safe, I think, to consider it a remnant of a partly occluded complete suture. Tarenetzkij [17] would distinguish the incisures from remnants of complete divisions by the greater height of the malar in which a complete division had existed than that of its mate, but such a criterium, though theoretically seemingly correct, meets in practice with numerous difficulties. Not many malars, even though entirely free from divisions, are exactly equal. The presence of partial divisions, especially when large, is probably not without influence on the size of the bone. Where a complete suture had existed but became early subject to partial obliteration, the size of the malar was undoubtedly less affected than in the cases where the suture remained patent until more advanced life. Finally, where a bilateral complete division existed, if obliteration on the two sides proceeded simultaneously, the malars would be liable to be of a very nearly equal size, and the indications of a complete suture would be absent; or, had the occlusion proceeded with much difference in time, the two malars would be unequal, and we should be predisposed to consider only the incisures in the larger malar as the remnants of a complete suture.

Actual measurements bear out well the uncertainty of basing any conclusions upon the difference in the size of the malars. Taking at random one hundred skulls of Peruvians of both sexes, in whom both malars were well preserved and the malar articulations were free from any signs of occlusion, I measured the dimension of the malar mostly affected by a transverse division, namely, the height of the body of the bone. The measurements were taken with a sliding compass at the middle of the bone, parallel with the malo-maxillary suture. Among the one hundred skulls there were seventy-two in which the malars showed no division, sixteen in which both malars showed a posterior incisure,[18] four in which the right, and seven in which the left, malar presented a posterior incisure, and one in which both malars showed both posterior and anterior incisures. The results of the measurements, which hardly need any comment, will be found in the table on the opposite page.

[17] Tarenetzkij. *Mém. de l'Acad. Imp. de Sci. de St. Pétersbourg*, tome xxxvii, No. 13 (1890), p. 39. [18] Only lineal incisures above 1 mm. in length considered.

	Equal.	Larger by 0.5 mm.		Larger by 1 mm.		Larger by 1.5 mm.		Larger by 2 mm.		Larger by 2.5 mm.		Larger by 3 mm.	
		Left.	*Right.*	*Left.*	*Right.*	*Left.*	*Right.*	*Left.*	*Right.*	*Left.*	*Right.*	*Left.*	*Right.*
1) Malars with no division	29	6	5	10	9	5	2	1	1	0	2	2	0
2) Both malars with a posterior incisure .	3	3	1	0	3	3	0	2	0	1	0	0	0
3) Right malar with a posterior incisure .	1	0	0	1	0	0	0	0	0	1	1	0	0
4) Left malar with a posterior incisure .	3	0	2	1	0	0	0	0	1	0	0	0	0
5) Both malars with an anterior and a posterior incisure	0	1	0	0	0	0	0	0	0	0	0	0	0

Résumé :

	Equal.	Left Malar Higher.	Right Malar Higher.
1)	29	24	19
2)	3	9	4
3)	1	2	1
4)	3	1	3
5)	0	1	0

The incomplete malar divisions occur in whites, according to various authors,[19] with the following frequency:

Gruber found the posterior incisure among 4000–5000 mainly Russian skulls in 428, or 8.5 to 10.7% and among 50 skulls of children and embryos in 7, or 14%.
Meyer found the incisures among 517 German skulls in 20, or 3.9%; among 42 Russian skulls in 3, or 7.1%.
Tarenetzkij found the incisures among 45 French skulls in 2, or 4.4%; among 416 Russian skulls in 28, or 6.7%.
Anutschin (source and kind of incisures not stated) in 1.2%.[20]
Matiegha found among 300 Czech skulls the posterior incisures in 22, or 7.3%; in anterior incisures in 6, or 2.0% of the cases.

All the authors who examined various ethnic crania for the partial malar divisions (Meyer, Sarasin, Tarenetzkij, Anutschin, Koganei, etc.) found them to be more frequent in almost all other peoples (Australians excepted, Anutschin) than in the whites.

In the human skulls that I have examined for this condition the partial malar divisions were distributed as shown in the tables on pages 290 and 291.[21]

The data given on these pages show plainly:

1. A considerably greater frequency of partial malar divisions in the American aborigines than in the whites. This excess in the partial is not associated with any corresponding excess in the complete divisions.

2. The divisions among the American aborigines occur relatively more frequently in the females than in the males and most frequently in children; however, the differences in the percentages in these three groups are not excessive.

3. The posterior divisions greatly preponderate in frequency over the anterior ones.

4. Both the anterior and posterior incisures are much more frequently bilateral than unilateral.

[19] In part after Matieghka.

[20] Has unusually low percentages with all the groups examined — apparently some individual peculiarity in recording.

[21] Only plainly marked incisures above one millimeter in length counted. All skulls in which there were signs of synostosis in the malar articulations were excluded. The material examined belongs to the collections of the American Museum of Natural History and the College of Physicians and Surgeons, New York City.

No malar incisures were found in the Australians and Polynesians. Among the various American tribes, the largest proportions of the incisures were found among the Peruvians and the Southern Utah Cliff Dwellers, but in general the data on the Americans, or at least those on the better represented tribes, show a considerable agreement.

In mammals below man malar incisures appear to be very rare. However, I found some instances of the condition in monkeys and a bear. The cases in monkeys, besides those mentioned, are as follows:

Cynocephalus porcarius (No. 10,277, *A. M. N. H.*). — The left malar shows dorsally a marked anterior incisure, beginning in the maxillary border of the bone a short distance above the antero-inferior angle and directed obliquely upward and backward.

The skull of a young Cynocephalus (No. 135, *C. P.* and *S.*) shows on each side an anterior malar incisure somewhat similar in location and direction, but smaller, particularly on the right, to that in the preceding case.

In a *Cercocebus mona* (No. 5025, *A. M. N. H.*) a 0.5 cm. long, horizontal incisure divides slightly above its middle the temporal process of the left malar.

The subject of partial malar divisions could be finished here were it not for two other forms of incisure which are met with on the bone.

The first of these incisures, already mentioned, is the one which occurs at the base of the frontal process of the malar in some animals. It is common in younger American bears; it is also occasionally found in seals and other pinnipeds, but is rarely seen in other classes of mammals. This division is a remnant of a complete separation of the frontal process of the malar; no analogous incisure has been found thus far in man, apes, or monkeys.

The second special form of partial malar division seems to occur only in man. It consists of a more or less marked, vertical, or more often somewhat oblique, frequently bilateral incisure, which runs downward from some part of the malo-frontal suture. So far as I can find, this incisure has not yet

No. of Skulls.		Sex.	Anterior Incisures.			Posterior Incisures.			No Incisures.
			Right only.	*Left only.*	*On Both Sides.*	*Right only.*	*Left only.*	*On Both Sides.*	
72	Whites	M.	—	—	—	4, or 5.6%	3, or 4.2%	6, or 8.3%	59, or 81.9%
50	"	F.	—	—	—	1, or 2%	—	2, or 4 %	47, or 94%
5	"	Children	—	—	—	1, or 20%	—	—	4, or 80%
10	African Negroes	M.	—	—	—	—	—	1, or 10%	9, or 90%
6	" "	F.	—	—	—	1, or 16.7%	—	—	5, or 83.3%
9	Australians and Polynesians. .	M.	—	—	—	—	—	—	9, or 100%
11	" " " . .	F.	—	—	—	—	—	—	11, or 100%
	Americans:								
4	Esquimaux	M.	—	—	—	—	—	1, or 25%	3, or 75%
2	"	F.	—	—	—	—	—	1	1
2	"	Children	—	—	—	—	—	—	2
17	Northwest Coast Indians . . .	M.	—	—	—	—	—	3, or 17.6%	14, or 82.4%
9	" " " . . .	F.	—	—	1, or 11.1%	2, or 22.2%	—	—	6, or 66.7%
11	Eastern and Middle States Indians	M.	—	—	—	—	—	—	11, or 100%
4	" " " " "	F.	—	—	1, or 25%	—	1, or 25%	—	2, or 50%
1	" " " " "	Children	—	—	—	—	—	—	1
	Southwest:								
40	Southern Utah Cliff Dwellers .	M.	—	—	1, or 2.5%	—	6, or 15%	10, or 25%	23, or 57.5%
7	" " " " .	F.	—	—	—	1, or 14.3%	—	—	6, or 85.7%
7	" " " " .	Children	—	—	—	—	—	4, or 57.1%	3, or 42.9%
17	Pueblos	M.	—	—	—	—	1, or 5.9%	3, or 17.6%	13, or 76.5%
4	"	F.	—	—	1	—	—	—	3, or 75%
6	"	Children	—	—	1, or 16.7%	—	—	1, or 16.7%	4, or 66.7%

	Mexico:								
15	Tarahumares	M.	—	—	—	1, or 6.7%	—	1, or 6.7%	13, or 86.7%
17	"	F.	1, or 5.9%	—	1 also post., or 5.9%	—	—	1, or 5.9%	14, or 82.4%
5	"	Children	—	—	—	—	—	1, or 20%	4, or 80%
62	Tarascos	M.	—	—	1, or 1.6%	2, or 3.2%	2, or 3.2%	3, or 4.8%	54, or 87.1%
18	"	F.	1, or 5.6%	—	—	1, or 5.6%	—	4, or 22.2%	12, or 66.7%
4	"	Children	—	—	—	—	—	3, or 75.0%	1, or 25%
63	Various parts of Mexico . . .	M.	—	—	—	1, or 1.6%	4, or 6.3%	7, or 11.1%	51, or 80.9%
29	" " " " . . .	F.	1, or 3.4%	—	—	1, or 3.4%	2, or 6.9%	5, or 17.2%	20, or 69%
4	" " " " . . .	Children	—	—	—	1, or 25%	—	1, or 25%	2, or 50%
70	Peruvians (1st Series)	M.	—	—	—	2, or 2.9%	7, or 10%	16, or 22.9%	45, or 64.3%
30	" " "	F.	—	—	—	4, or 13.3%	—	8, or 26.6%	18, or 60%
82	Peruvians (2d Series)	M.	1, or 1.2%	—	1, or 1.2%	4, or 4.9%	6, or 7.3%	14, or 17.1%	55, or 67.1%
20	" " "	F.	—	—	—	—	3, or 15%	3, or 15%	14, or 70%
12	" " "	Children	—	—	—	—	1, or 8.3%	3, or 25%	8, or 66.7%
92	Peruvians (3d Series)	M.	—	—	1, or 1.1%	3, or 3.2%	6, or 6.3%	15, or 16.3%	67, or 72.8%
8	" " "	F.	—	—	—	1, or 12.5%	1, or 12.5%	1, or 12.5%	5, or 62.5%

Totals of American Aborigines.	Anterior Incisures.			Posterior Incisures.			No Incisures.
	Right only.	*Left only.*	*On Both Sides.*	*Right only.*	*Left only.*	*On Both Sides.*	
473 Males	1, or 0.2%	—	4, or 0.8%	13, or 2.7%	32, or 6.8%	73, or 15.4%	350, or 74%
148 Females	3, or 2%	—	4, or 2.7%	10, or 6.8%	7, or 4.7%	23, or 15.5%	101, or 68.2%
41 Children	—	—	1, or 2.4%	1, or 2.4%	1, or 2.4%	13, or 31.7%	25, or 61%

been described. I have met with it in the skulls of whites as well as in those of Indians. It is a rare condition, much more rare in the Indians than the divisions in the posterior portion of the malar. Thus far I have found no specimen which would offer an explanation of the significance of this superior incisure. Occasionally, as in the specimen illustrated in the accompanying figure, it is in a curving line with several malar foramina.

FIG. 11.

In my examination for malar divisions I came across three specimens which may prove of interest in connection with this paper.

In looking over the few bear skulls in the collection in the College of Physicians and Surgeons (New York), I found one with a peculiar anomaly present on both sides. Both malar bones in this specimen show a partial separation of the frontal process, but no other division. There is, however, on each side a complete separation, by a previous, well-serrated suture, of that portion of the zygomatic process of the temporal bone which covers the temporal process of the malar (Fig. 12).

The two other specimens are human malars (Nos. 1068 and 1069, College of Physicians and Surgeons, New York), one of which shows the marks of a complete, the other those of an incomplete, vertical fracture. Both of these malars present a pronounced depression over their temporal portion.

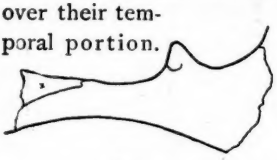


FIG. 12.

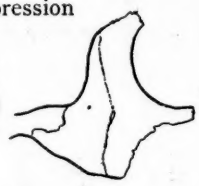


FIG. 13.

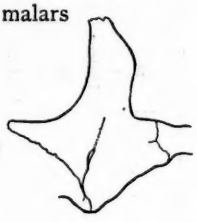


FIG. 14.

Some force was undoubtedly applied to this point, and the malar bone was fractured over and along the line of the internal malo-maxillary articulation. The border of the maxillary articular surface acted as a fulcrum over which the bone broke. There is no callus formation, and both cases bear some resemblance to a malar suture (Figs. 13 and 14).

In connection with the search for malar incisures in Indians two other points were noted, namely, the lineal, antero-posterior groove on the ventral surface of the malar (Gruber) and the temporo-maxillary arc. The groove was found to be almost constant, while the arc is generally more or less incomplete.

NOTE.

While my paper on malar divisions has been in the hands of the printer, the American Museum of Natural History has received two skulls of adult African lions, one of which shows a partial malar suture.

The suture is in the left malar; the right malar has been fractured (post-mortem), and its posterior half is wanting. Dorsally, the separation runs sagittally from a point slightly posterior to the angle of the temporal border of the malar and a somewhat greater distance anterior to the zygomatic suture, over more than half of the malar, after which it bends downward and terminates; the division is somewhat serrated and contains five small Wormian ossicles. Ventrally, the malar suture runs in a serrated manner a short distance forward and unites with the boundary of a large Wormian bone, the anterior extremity of which reaches to a point slightly posterior to the dorsal termination of the suture.

FIG. 15.

The malar shows no signs of any recent or old injury, and the division is undoubtedly congenital. It is probably a remnant of a complete malar suture, the anterior extremity of which became subject to an early synostosis. The curving anterior end can be explained by a simultaneous excess in growth of the anterior portion of the superior, and the posterior portion of the inferior, part of the malar.

The frontal process of the bone shows in its summit a vertical incisure.

There are eighteen other lion skulls of various ages in the Museum, but in none of these is there any indication of a sagittal malar division.

COLLATERAL BUDDING IN ANNELIDS OF THE GENUS TRYPANOSYLLIS.

HERBERT PARLIN JOHNSON.

ASIDE from the marvelous development of an extensively branching stock in *Syllis ramosa*, the only mode of asexual proliferation hitherto known among annelids is the linear stolonization so well exemplified by species of Autolytus, Myrianida, Procerastea, Nais, and a few other genera of small chætopods. Previous to the discovery of the extraordinary forms about to be described, the production of numerous *collateral* buds from a definite and circumscribed proliferating region has never, it is safe to say, been even imagined as among the possibilities of annelid development.

As briefly announced more than a year ago,[1] two species of Syllidæ living on our Pacific coast have been found to produce sexual zooids by collateral budding. These I have studied as fully as the scanty material permits, and the results, though far from complete, are, I trust, of sufficient interest to warrant their publication, particularly as the obtaining of more material is a matter of great uncertainty.

Both species undoubtedly belong to the genus Trypanosyllis as defined by Malaquin,[2] and both are unusually large for syllidians. The larger, for which the name *Trypanosyllis ingens* is proposed, is a veritable giant of its kind, measuring 13 cm. in length, exclusive of the tail buds, and 6 mm. in width. The only specimen of this rare species I have seen was given to me by Prof. Harold Heath of Stanford University, to whom my grateful acknowledgments are due. It was found by him under a stone between tide marks, at Pacific Grove, California.

[1] Johnson, H. P. A New Type of Budding in Annelids. Paper read at the eleventh annual meeting of the American Morphological Society at Baltimore, Dec. 27, 1900. An abstract was published in the *Biological Bulletin*, vol. ii, No. 6 (1901). [2] Malaquin, A. *Recherches sur les Syllidiens*, p. 72. Lille, 1893.

The worm is much flattened in the horizontal plane, measuring only 2 mm. in its greatest dorso-ventral diameter. The parapodia (Fig. 1) are very diminutive for the size of the trunk, and the somites are so short that the stout dorsal cirri (inasmuch as their thickness exceeds the length of the somites) form an alternating series. The somites number nearly 500.

As *Trypanosyllis ingens* is undoubtedly new to science, a diagnostic description, with figures sufficient for its identification, is given. It is unfortunately too rare to serve as a

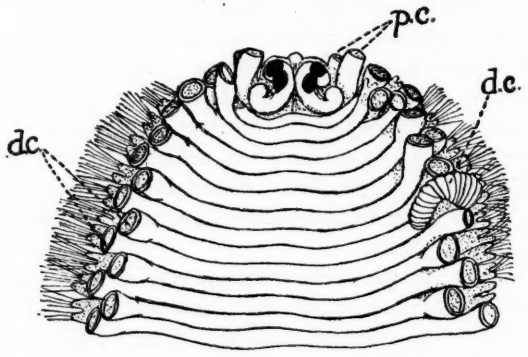


FIG. 1. — Anterior extremity of *Trypanosyllis ingens*. The palpi, antennæ, median cirrus, peristomial cirri, and all the dorsal cirri, with one exception, are broken off at the basal constriction. *p.c.*, peristomial cirri; *d.c.*, dorsal cirri. × 12.

subject for study of collateral budding. It occurs in none of the numerous gatherings of Pacific coast Polychæta that came into my hands during six years' residence in California; and Dr. Heath, who has done a great deal of collecting at Pacific Grove and vicinity at all seasons of the year, informs me that he has found only this specimen.

Trypanosyllis ingens sp. nov.

Form elongated, broad, much depressed; dorso-ventral differentiation very slight, dorsum slightly convex, ventral surface plane, longitudinally bisected by a narrow median welt, sharply bounded by two fine parallel grooves; extremities evenly and abruptly rounded off; slightly more tapered posteriorly than anteriorly; somites very short, crowded, about 476 in number.

General coloration tawny; parapodia, dorsal cirri, and anterior extremity, purple; caudal buds, from presence of ova, rich yellow.

Prostomium (Fig. 1) trapezoidal, its length two-thirds of its width, distinctly bilobed, the lobes scroll-shaped, with a deep median notch at posterior border; eyes 4, on anterior scrolls, connate. Palpi, antennæ, and median cirrus, all wanting in the type specimen.

Peristomium somewhat broader than the prostomium, enclosing the latter posteriorly and on the sides; with dorsal and ventral peristomial cirri (Fig. 1, *p.c.*).

Parapodia uniramous, short, crowded, with bases of the dorsal cirri interlocking (Fig. 1, *d.c.*); dorsal cirri (Fig. 2, *d.c.*) thick, coiled, articulated, rather rapidly tapering towards the tip; ventral cirrus tongue-shaped or fusiform; setæ (Fig. 3) 11–13 in each foot, with toothless hooked appendage; aciculæ (Fig. 2, *ac.*) 3–5, their distal ends extending into two finger-like lobes, one usually much thicker than the other, at the dorsal tip of the foot.

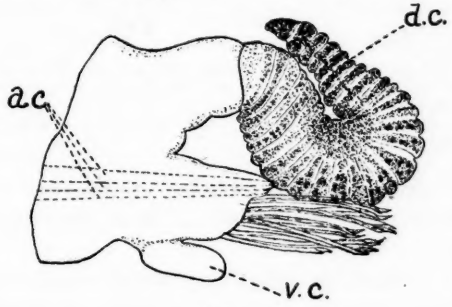


Fig. 2. Fig. 3. Fig. 4.

Fig. 2. — Foot of *Trypanosyllis ingens*, from about the middle of the length. *ac.*, aciculæ (three); *d.c.*, dorsal cirrus; *v.c.*, ventral cirrus. × 30.

Fig. 3. — Seta of the same, in profile. × 467. Fig. 4. — Seta, sexual zooid of the same. × 467.

Mouth large, its transverse diameter equal to width of prostomium; bounded by 7 crenulations. Somites 1–8 curved backward around mouth, as in Amphinomidæ and Palmyridæ.

Proboscis short and small (2 mm. long), thin-walled, bounded posteriorly by a double ring of fleshy papillæ, 9–10 in each ring, those of the outer circle more than twice as long as the inner ones.

Œsophagus short (3.5 mm.), and of small diameter (1 mm.) for the size of the animal, with usual chitinized lining, which terminates in a "trephine" anteriorly. Œsophagus surrounded

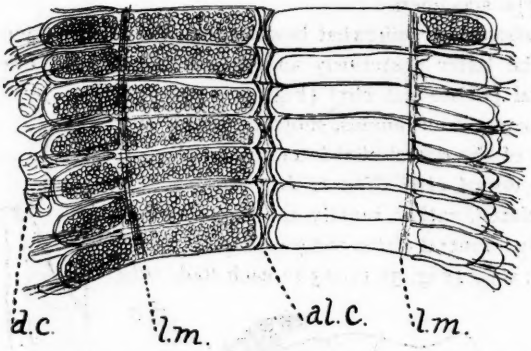


FIG. 5.—Seven somites from the middle region of a female sexual zooid of *Trypanosyllis ingens*, viewed from the dorsal aspect. With two exceptions (*d.c.*) the dorsal cirri are broken off. The rudimentary alimentary canal (*al.c.*) is indicated; also the ova on the left side and in one parapod on the right. The longitudinal muscle bands (*l.m.*) mark the bases of the parapodia. In clove oil. × 19.

by 9–10 glands, of wavy or crenulate outline, opening near the papillæ, their blind ends extending back a short distance on the proventriculus.

Proventriculus also small for size of the animal, 6 mm. long, 1.5 mm. in greatest transverse diameter, slightly club shaped, thickest anteriorly, tapering gradually to posterior end; two well-defined raphes. No cœca were detected.

Intestine with extensive paired diverticula in every somite back of the proventriculus.

Sexes distinct; sexual products, so far as known, developed only in a cluster of collateral buds, growing from a definite proliferating region near the posterior end; probably also in the parental somites posterior to the budding zone.

Length, 130 mm.; greatest transverse diameter, including parapodia, 6 mm.; dorso-ventral diameter, 2 mm.

Habitat, Pacific Grove, California; between tide marks.

The form seemingly most nearly allied to *T. ingens* is *Trypanosyllis gigantea* (M'Intosh) Ehlers of the Southern Ocean. The latter is but little inferior in size, measuring, according to M'Intosh,[1] 90 mm. in length and 7 mm. in breadth. The form

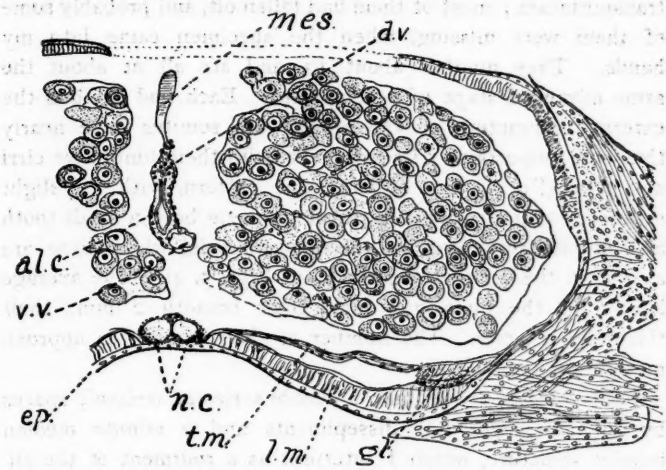


FIG. 6.—Transverse section, female zooid of *T. ingens*, right half. A portion of the dorsal body wall (indicated by dotted lines) is broken away. The plane of the section encounters the septum on the right. *al.c.*, rudimentary alimentary canal; *d.v.*, dorsal blood vessel; *v.v.*, ventral ditto; *mes.*, dorsal mesentery; *gl.*, problematic glandular structure (external extremity); *n.c.*, nerve cords; *l.m.*, longitudinal musculature; *t.m.*, transverse muscle; *ep.*, epidermis. × 100.

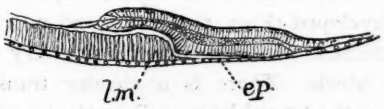


FIG. 6 *A*.—Problematic gland-like tube, from right side of another section of the same series, with portion of body wall adjacent. The external extremity (aperture?) is toward the right. The tube is laid open by the section, showing ends of columnar cells. Lettering as in Fig. 6. × 100.

is very similar, the parapodia of both have multiple aciculæ (6 in *T. gigantea*), and the setæ of the two species are practically identical. There is nothing, however, in M'Intosh's description or in his figure of a cross-section to indicate that

[1] M'Intosh, W. C. Challenger Reports. *The Polychæta*, vol. xii (1887), p. 193.

T. gigantea has the great intestinal diverticula so conspicuous in *T. ingens* and in *T. gemmipara* (Fig. 16). The prostomium of *T. gigantea* is also of simpler form.

Unfortunately the delicate tail buds of this formalin-preserved specimen were somewhat macerated and broken in transportation ; most of them had fallen off, and probably some of them were missing, when the specimen came into my hands. They number about 30, and are all at about the same advanced stage of development. Each bud exhibits the external characters of the stock. Its somites have nearly the same proportions ; its parapodia, with their diminutive cirri and setæ (Fig. 5), are of the same pattern, with the slight difference that the appendages of the setæ have a small tooth and minute serrations on the concave side, while these are absent in the setæ of the stock (*cf.* Figs. 3, 4). The average length of the buds is 5 mm., their breadth 2 mm., their thickness 0.5 mm. The number of their somites is approximately 25.

Each zooid is divided into a double series of cœlomic spaces by the intersegmental dissepiments and a minute median tubular structure, which I interpret as a rudiment of the alimentary canal (Figs. 5, 6, *al.c.*). The cœlomic spaces, including even the parapodial cavities (Fig. 5), are packed full of eggs, which possess very large nuclei and nucleoli, the latter usually vacuolated (Fig. 6). No ova have been found in the parent stock. The longitudinal muscular system of the bud is not highly developed (Figs. 5, 6, *l.m.*), and no circular musculature was detected. Circular muscles are very slightly developed in the stock. There is a slender transverse muscle extending from the lateral body wall to the nerve cord (Fig. 6, *t.m.*). This, however, I suspect is not so much a separate muscle as a portion of the very extensive system of septal muscles.

A dorsal and a ventral blood vessel (Fig. 6, *d.v.*, *v.v.*) are seen close to the digestive tract. The ventral vessel with its coagulum is apparently of uniform diameter throughout its course, while the dorsal vessel is segmentally constricted (Fig. 6 represents a constricted place). No lateral branches have been detected.

A pair of problematic organs, possibly much-modified nephridia, are present in each segment. These organs are tubular, with rather narrow lumen, their thick walls composed of columnar, much-vacuolated cells (Fig. 6 *A*), and no opening has been seen at either extremity. They occupy a ventral position, the internal extremity being directed towards the median line, and the outer extremity obliquely towards the

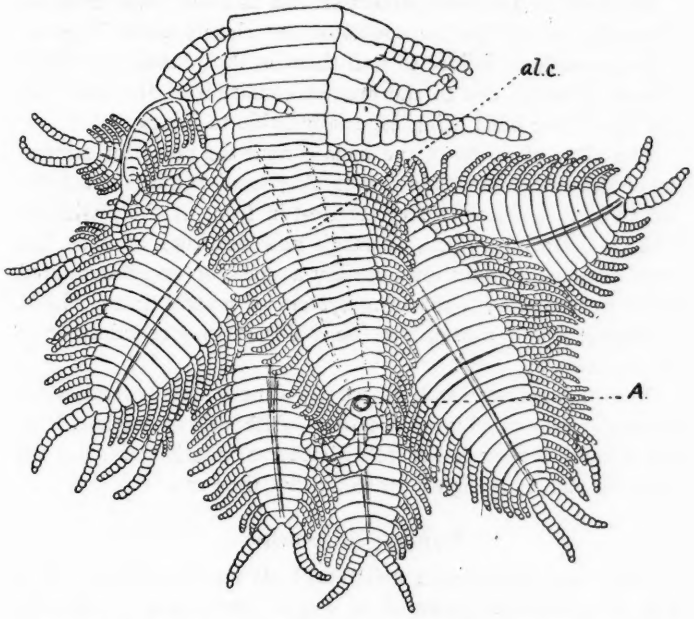


FIG. 7.—Caudal buds of *Trypanosyllis gemmipara*, dorsal aspect. The posterior ciliated portion of the intestine (*al.c.*) and the anus (*A*) are shown in the attenuated caudal portion of the stock. × 26.

ventral body wall, which it penetrates as far as the epidermis. It is known that in several species of syllidians the segmental organs serve as genital ducts, and for this purpose undergo enlargement at sexual maturity.[1] Such a function would seem to be impossible in this instance when we compare the diameter of the ova with the diameter of the tubes.

[1] Ehlers, Ernst. *Die Borstenwürmer* (1864), p. 215.

A pair of ventral nerve cords (Fig. 6, *n.c.*) are conspicuous in transverse sections, in which the cut ends of the nerve fibers appear, surrounded at intervals by a few darkly stained bodies, the nuclei of ganglionic cells. The ganglia, one to each segment, can be plainly seen in a zooid cleared with glycerine. The nerve cords, although in direct contact with the epidermis, are plainly not fused with it.

No head or eyes were detected; but as these structures are obviously present in the zooids of the closely allied *Trypanosyllis gemmipara*, failure to find them in the present species is almost certainly due to the broken condition of the material, the tips of the buds being especially liable to injury.

The place of origin of the buds is near the posterior extremity of the stock. Probably, as in *T. gemmipara*, it is about the length of a zooid, or twenty somites, in front of the pygidium. The proliferating region, although now destitute of buds, has been sectioned, and shows merely a mass of undifferentiated tissue pervaded by a radiating system of muscle fibers, which, in all probability, passed into the zooids, as they certainly do in *T. gemmipara*.

The rudimentary and apparently functionless condition of the alimentary canal is noteworthy. Although impossible, from the defective material, to tell whether a mouth and anus are really absent, it is highly probable that they are.

Trypanosyllis gemmipara.

The other species with collateral buds was found in a collection of Polychæta gathered in Puget Sound and vicinity by Nathan R. Harrington, since deceased, member of the expedition sent out by Columbia University in the summer of 1896. It has been described and figured in the writer's report[1] on the Polychæta of that expedition under the name *Trypanosyllis gemmipara*.

Although much smaller than the preceding, *T. gemmipara* is nevertheless very large for a syllid. The Puget Sound specimen measures 68 mm. in length and 3 mm. in width. Like

[1] Johnson, H. P. The Polychæta of the Puget Sound Region, *Proc. Boston Soc. Nat. Hist.*, vol. xxix (1901), No. 18, p. 405, Figs. 72–76.

T. ingens, and in fact most, if not all, species of this genus, *T. gemmipara* is much flattened horizontally, being only 1 mm. in dorso-ventral diameter. The somites number about 300, and, as in *T. ingens*, their width many times exceeds their length.

The tail buds, 50 in number, present all stages of development. They form a tuft arising from the ventral aspect near the posterior extremity, and superficially resemble a bunch of

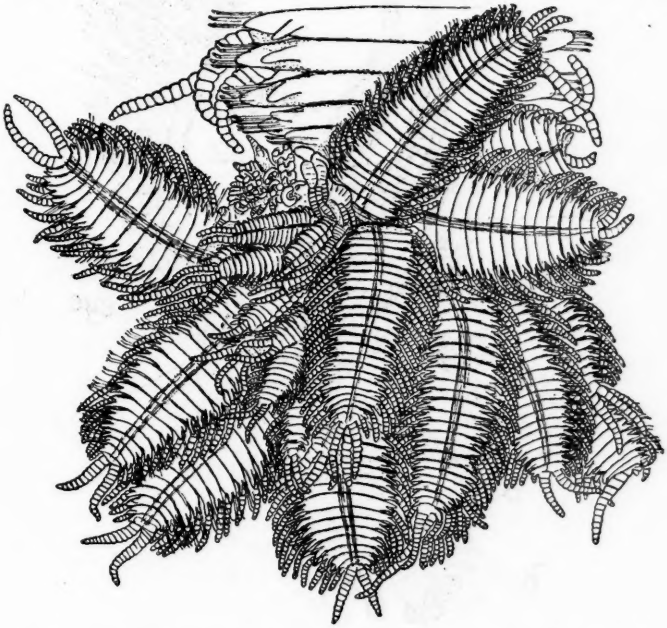


FIG. 8. — Caudal buds, ventral aspect, of *T. gemmipara*. The young buds are seen on the left of the figure. × 26.

ferns (Figs. 7, 8). Neither as regards position nor order of development do they obey the laws of bilateral symmetry. The whole cluster is bent to the right, making an angle of about 25° with the longitudinal axis of the worm. Only 13 of the buds have reached an advanced stage of development; these are elliptical in shape, rather thin in proportion to their other dimensions, and possess the chief external characters of

the parent. Their somites are 20 to 28 in number; their small but well-developed parapodia are furnished with moniliform dorsal cirri and minute setæ of the same form as those of the parent. The average length of a mature bud is 2.5 mm.;

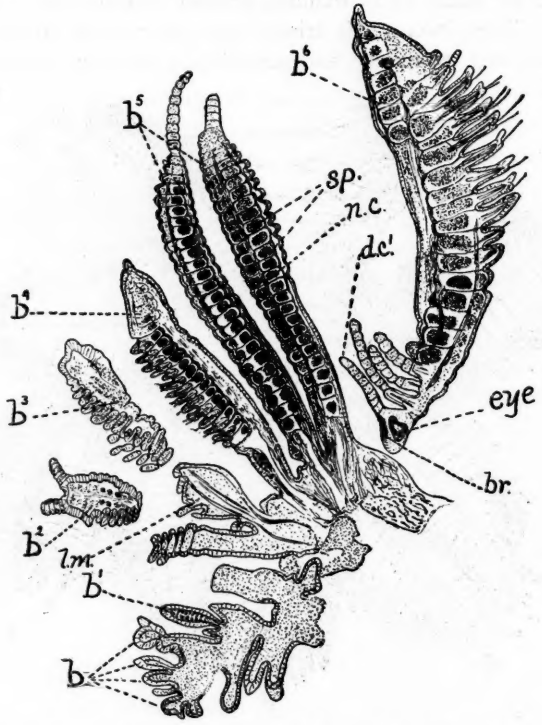


FIG. 9.— Frontal section through budding zone of *T. gemmipara*, showing male zooids at different stages (*b*–*b*⁶) of development. The zooids are cut at various planes (the two in the center of the figure, marked *b*⁵, nearly in the median sagittal plane). The youngest buds are marked *b*; *b*¹ indicates a bud in which segmentation is just beginning; *b*², *b*³, buds in which segmentation is completed except at distal end, and the parapodia are already well developed; *b*⁴–*b*⁶, buds progressively older; *br.*, brain; *d.c.*¹, first dorsal cirrus; *l.m.*, longitudinal muscles; *n.c.*, nerve cord; *sp.*, sperm cells. × 50.

the breadth, including parapodia, is 1 mm. The bud tapers more towards the caudal than towards the cephalic extremity. The anal cirri are longer and thicker than any of the dorsal cirri (Figs. 7, 8).

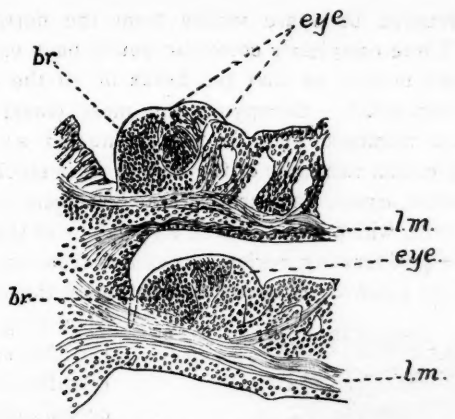


FIG. 9 *A*. — Anterior extremities of zooids marked b^5 in Fig. 9, showing, at two different stages, the *Anlagen* of eye and brain as they appear in a section further from the median plane of the zooids than that represented in Fig. 9. The extension of the ventral longitudinal muscles of the zooids into the proliferating zone of the stock is clearly indicated. Lettering as in Fig. 9. × 200.

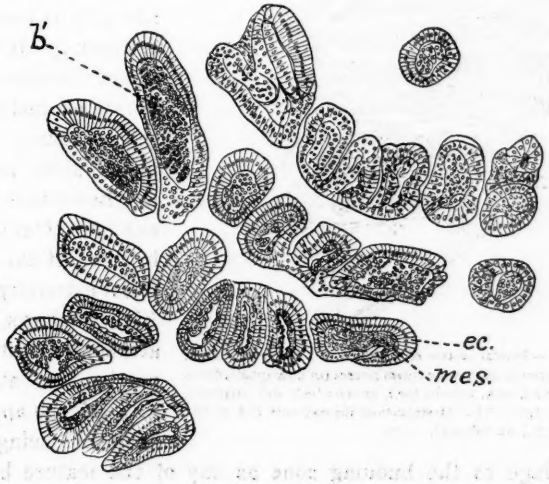


FIG. 9 *B*. — Transverse section of group of young buds, taken in same direction (frontal), but at lower level than Fig. 9. The arrangement in transverse rows is clearly indicated. Buds at extreme left are cut obliquely; in one of these (b^5), segmentation of the mesoderm is beginning. *ec.*, ectoderm; *mes.*, mesoderm. (Semidiagrammatic.) × 147.

Only advanced buds are visible from the dorsal aspect (Fig. 7). These completely cover the young buds on the ventral side and overlap so that the heads of all the advanced buds are concealed. Occupying the most dorsal position amongst the advanced buds is the attenuated and rapidly diminishing caudal extremity of the stock. It is much like the buds in general aspect, and further resembles them in containing sperm cells, which are absent in all portions of the stock in front of the proliferating region. It differs from the buds in possessing (1) a heavily ciliated continuation of the alimentary canal (Fig. 7, *al.c.*), (2) the anus, and (3) differs in lacking cephalization. In every respect except that it contains sperm cells, it resembles a regenerated posterior extremity. It possesses twenty-four somites, including the pygidium. The proliferating region is therefore this number of somites in front of the posterior extremity. As Fig. 7 shows, the attenuated posterior portion has almost as much the appearance of being an appendage to the budding zone as any of the mature buds.[1]

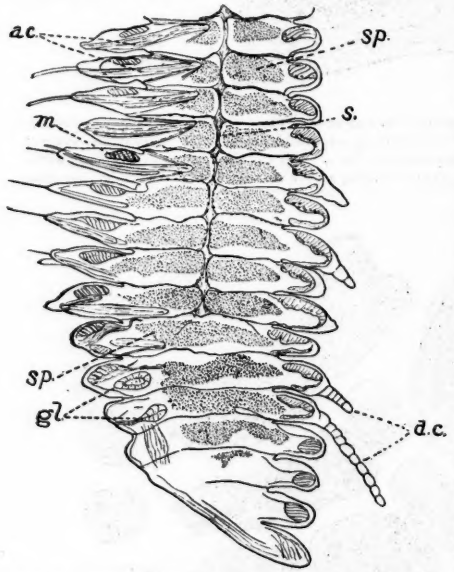


FIG. 10. — Frontal section of a portion of a full-grown bud of *T. gemmipara*, showing sperm masses (*sp.*), parapodia, dorsal cirri (*d.c.*), setæ, aciculæ (*ac.*), muscles (*m.*), and parapodial glands (*gl.*). The intersegmental dissepiments and median strand (*s.*) are indicated. × 75.

It is worthy of note that into this region the deep intestinal

[1] This attenuated posterior extremity is probably a permanent feature. I have found it in every entire specimen of *T. gemmipara* I have collected on the California coast, but the number collected is small.

diverticula do not continue. The diverticula of this portion of the alimentary canal are very shallow, and were not detected in the entire specimen (Fig. 7).

The attachment of the buds to the proliferating area (invisible in the entire specimen) is by a short unsegmented pedicle at the cephalic extremity of each bud (Figs. 9, 9 *A*, 17, *p.*). There is no distinct prostomium. The head is merely the eye- and brain-bearing first segment, which shows its primitive character by also carrying parapodia equipped with dorsal cirrus, setæ, and aciculæ (Fig. 9, *d.c.'*). This fact is significant, because it is exactly what we find in the stolons of not a few syllidians, among others those of *Trypanosyllis krohni*.[1]

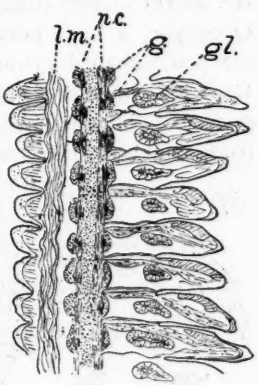


FIG. 11.— Frontal section at a lower level, showing paired nerve cords (*n.c.*), ganglia (*g.*), ventral longitudinal muscle (*l.m.*), and parapodial glands (*gl.*). × 75.

The eyes, apparently only two (although each may represent two, completely fused), are large and highly developed, as is often the case in stolons. There is a well-defined lens (Fig. 15, *l.*), a "vitreous body" (*vt.*) composed of the rods of the retinal cells, and a very thick, cup-shaped retina, the inner layer of which contains a small quantity of brown pigment (*p.*), but not dense enough to conceal its structure.

The buds are destitute of an alimentary canal, unless the merest rudiment exists in the form of a median strand (Figs. 10, 12, *s.*). Certainly there is no tubular structure such as occurs in the bud of *T. ingens*. There is no mouth, anus, or blood vessels. The zooid is sharply divided by the dissepiments and an incomplete median partition into a double series of cœlomic spaces. That the right-and-left cœlomic chambers of the same somite are sometimes continuous is clearly shown by the sperm masses in the more posterior segments represented in Fig. 10. This seems to be the case only in the ventral portion of the chamber. The sperm masses do not

[1] See Malaquin, *op. cit.*, Pl. X, Figs. 18, 19.

completely fill the spaces, and do not seem in any case to occupy the cavities of the parapodia. Spermatozoa were not observed in any of the buds, indicating that even the oldest are not fully ripe.

The parapodia are fully equipped with dorsal and ventral cirri, setæ, a pair of aciculæ, — the latter projecting deeply into the sperm masses (Fig. 10, *ac.*), — and the usual musculature. Occupying a large portion of the cavity of each parapodium are pouch-shaped glandular structures of unknown function. Each is composed of a few very large vesicular cells, and has a good-sized lumen which appears to open near the base of the parapodium, on the ventral side (Figs. 10, 11, 13, *gl.*). No actual opening, however, has been found, and the mouth seems entirely blocked by columnar epidermal cells (Fig. 13). These glands occur in the segments of the attenuated caudal region, where they have the same size and aspect as in the buds. In the parapodia of the stock — at least those immediately in front of the budding zone — they are also found. Without much doubt these structures are homologous with the parapodial glands (*glandes pédieuses*) known to be present in *Trypanosyllis cœliaca* and in species of other genera of Syllidæ.[1] Their function is the secretion of mucus. From their histological aspect, this is probably likewise the function of the above-described glands.[2]

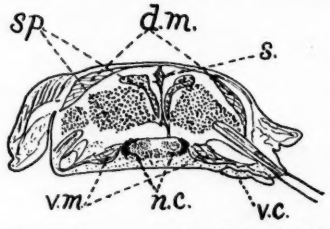


FIG. 12. — Transverse section of full-grown bud, *T. gemmipara*. *d.m.*, dorsal longitudinal muscles; *v.m.*, ventral ditto; *s.*, median strand; *v.c.*, ventral cirrus; *sp.*, masses of sperm cells; *n.c.*, ventral nerve cord, showing cut ends of fibers and ganglionic cells. × 100.

There are two large and conspicuous ventral nerve cords, with paired ganglia in every somite (Figs. 11, 12, *n.c.*, *g.*). Proportionately to the size of the bud, the nervous system is much larger in this species than in *T. ingens*. As accurately as could be made out from the single series of sections, the

[1] See Malaquin, *Recherches sur les Syllidiens*, p. 87, Pl. VII, Fig. 7.

[2] It is interesting to find that these glands are not only relatively, but absolutely, larger in the caudal segments and in the buds than in the stock.

nerve cords run forward to the cephalized extremity and there innervate the eyes and a darkly staining mass of ectodermic cells which probably functions as brain (Fig. 14, *cb.*). Although the nerve cords are plainly separate from the epidermis, as shown by a cross-section (Fig. 12, *n.c.*), the brain is no more than a thickened portion of the epidermis, and fully confluent with it. As clearly shown in one section (Fig. 14), the optic nerve comes from the ventral cord, and not from the brain.

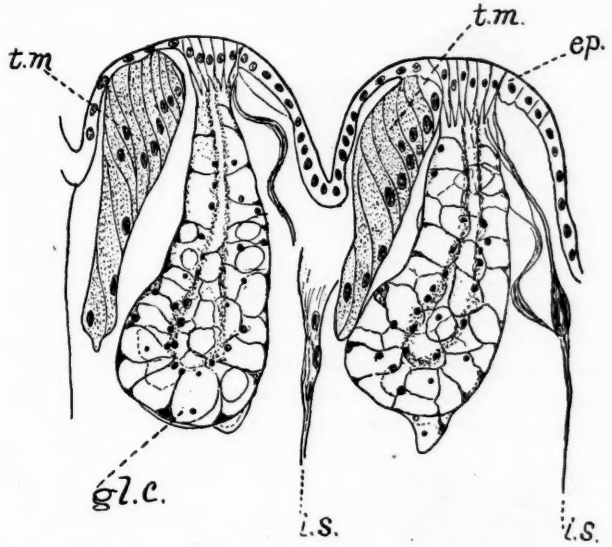


FIG. 13. — Two pedal (mucous?) glands of bud of *T. gemmipara*, in longitudinal section. The lumens of the glands are bounded by stippled bands; the gland cells (*gl.c.*) are highly vacuolated; the epidermal cells at mouth of glands are columnar. *t.m.*, transversal muscles; *i.s.*, intersegmental dissepiments; *ep.*, epidermis. × 525.

When viewed from the ventral aspect the cluster of buds presents an interesting condition of things (Fig. 8). On the right, at the base of the cluster, is a group containing about 25 very young buds (Fig. 8), as yet showing no segmentation, but each with two distal processes which are the *Anlagen* of the anal cirri. As may clearly be seen in a transverse section of the group (Fig. 9 *B*), the buds are arranged in rows, partly transverse and partly longitudinal as regards

the long axis of the stock. In a graduated series proceeding from the left side of the cluster of youngest buds are more advanced buds, the largest approaching the mature condition (Fig. 9, b–b^6). At an early stage the anal cirri attain a notable length and become articulated.

As shown in a frontal section (Fig. 9) through the proliferating region, the buds sprout from a mass of undifferentiated tissue traversed by muscle fibers which are continuous

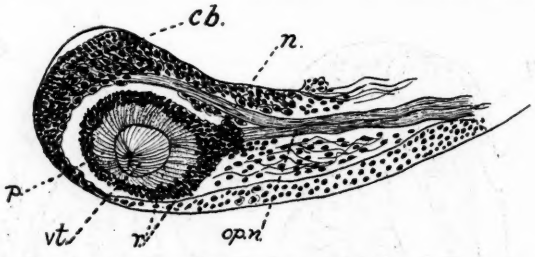


FIG. 14. — Frontal section of a portion of head, same bud as shown in Fig. 10. *n.*, nerve to brain (*cb.*); *op.n.*, optic nerve; *r.*, retina, showing rod cells and pigment (*p.*); *vt.*, "vitreous body," composed of the clear retinal rods. The nerve to the brain breaks up into numerous fibers, which are distributed to the ganglionic (?) cells. × 153.

with the longitudinal muscle bands of the buds (Fig. 9 *A*, *l.m.*). This mass is mesoderm, covered by ectoderm in the form of epidermis. Both ectoderm and mesoderm of the buds are continuous with the same germ layers of the proliferating region. Whether the proliferating mass comprises one or more than one somite cannot be positively stated from the sections at hand, which are defective at this point.

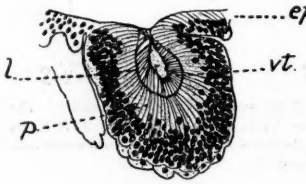


FIG. 15. — Longitudinal section of eye, showing its cup-like form, and apparent formation by an invagination of the epidermis (*ep.*). Lettering as in preceding figure; *l.*, lens. × 267.

At a very early stage the mesoderm undergoes segmentation, and the reproductive cells are discernible (Figs. 9, 9 *B*, *b'*).

No buds provided with special natatory setæ (*Pubertätsborsten*) such as usually occur in the stolons of syllids and in the sexual buds of *Syllis ramosa*[1] were observed.

[1] M'Intosh. *Challenger Reports*, vol. xii, p. 201, Pl. XXXIV A, Fig. 9.

General Considerations.

From the standpoint of comparative morphology, the collateral buds of Trypanosyllis may be regarded as structures of the same order as the stolons of Autolytus or Myrianida, but with the important difference that the buds in this case are lateral outgrowths, whereas in stolonization they are the result of linear growth and differentiation. As stolons, they extend the organic axis of the parent, and the alimentary canal passes through them all, to terminate at the anus located in the pygidium of the oldest stolon.

At first thought it would seem as though the buds of Trypanosyllis are more appropriately comparable to the sexual zooids of *Syllis ramosa*. The superficial resemblance to the latter is indeed striking. In both instances we have a lateral outgrowth of the stock, to which it is attached at the head end by a pedicle; in both, the zooids are the bearers of the sexual products (which do not develop in the stock), and both have an imperfectly developed prostomium bearing highly developed eyes. There are, however, two important points of difference: (1) the pedicle of the sexual zooid of *Syllis ramosa* is segmented, and the segments even bear rudimentary cirri[1]; (2) the sexual zooids as well as the asexual branches of *S. ramosa* contain a branch of the alimentary canal, fully continuous with that of the stock. In neither of these respects does the sexual bud of *T. gemmipara* in the least resemble the sexual bud of *S. ramosa*. The sexual zooids of the latter species are evidently specialized, fructifying branches of a widely branching asexual stock. They are equipped with large eyes and special swimming organs (natatory setæ), and break away from the parent stock at maturity. In all these respects they differ, it is true, from the purely vegetative branches, but these differences are merely adaptive to the special functions of insuring fertilization of the eggs and disseminating the species.

Whether the somite or somites from which the sexual buds of Trypanosyllis arise is to be regarded as homologous with the others cannot be decided from the material at hand. No

[1] M'Intosh. *Challenger Reports*, vol. xii (1887), Pl. XXXIII, Fig. 11.

somite unprovided with parapodia of the usual form was discovered. A recent study of *S. ramosa* by Oka[1] has brought out the interesting fact that the paired buds arise, not from one of the original somites, but from a newly developed, intercalated somite, which differs from all the others in lacking parapodia. Oka is doubtless right in regarding it as non-homologous with the other somites.

While the stolons of Autolytus and of syllidians generally are distinct and complete individuals provided not only with

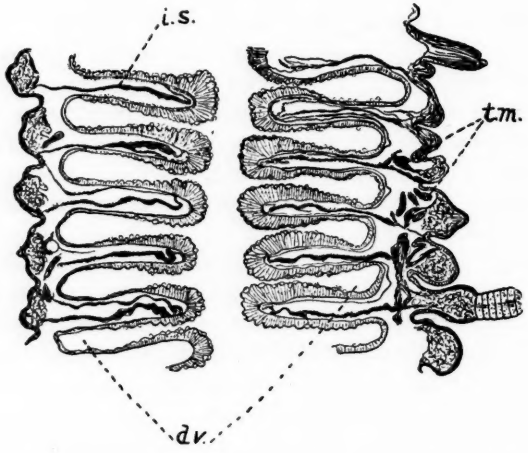


FIG. 16. — Frontal section of stock, *T. gemmipara*, showing the paired intestinal diverticula. The intestinal epithelium gradually thins towards the blind extremities of the diverticula. The intersegmental septa (*i.s.*) and some of the transversal muscles (*t.m.*) are shown. × 34.

sexual, sensory, and locomotor organs, but with those subserving nutrition, circulation, and excretion, the sexual buds of *T. ingens*, and even more strikingly *T. gemmipara*, exhibit a higher degree of specialization in lacking functionally developed vegetative organs. The zooid is therefore quite as incapable of leading a prolonged independent existence as the famed Palolo of the South Seas. It is no more than a living engine for the dissemination of the genital products which it carries,

[1] Oka, Asajiro. Ueber die Knospungsweise bei Syllis ramosa, *Zoölogical Magazine*, Tokyo, vol. vii (1895), p. 117.

and that duty must be accomplished solely by the expenditure of the stored-up energy which it has derived from the stock.

From the biological point of view the function of the zooids is the same, whether they arise by linear or by collateral budding. In both cases there is an alternation of generations exactly comparable to that of the Hydromedusæ. As regards *S. ramosa* the asexual stock is practically as sessile as the sponge in which it lives, and like sessile organisms of much lower grade it branches with great freedom and facility. It is not in the least surprising, therefore, to find such a form producing by lateral budding free-swimming zooids, which serve as special disseminators of the species and provide for a sexual reproduction in which cross-fertilization is assured.

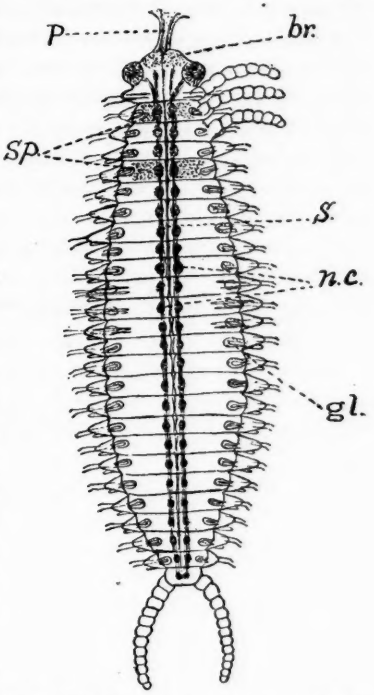


FIG. 17. — Ideal reconstruction of a mature male zooid of *T. gemmipara*. The dorsal cirri are omitted except on right side of three most anterior somites. The sperm masses are in every segment except the first and the pygidium, but are represented only in somites 2 and 5. The aciculæ are omitted except in first segment and three middle ones. *p.*, pedicle of attachment. Other lettering as in preceding figures.

In the forms under consideration the case is somewhat different. Notwithstanding their large size and heavy form, so different from the majority of syllidians, suggest that they are somewhat sluggish in their habits, neither of them can be considered as sessile. It is difficult to see, however, that they are any more inert than a multitude of annelids which have nothing aberrant in their mode of reproduction. Evidently some more precise explanation must be sought.

The fact that Trypanosyllis is a genus of the Syllidæ must not be overlooked. Of all the annelids, this family affords the best and most numerous examples of asexual reproduction by stolonization. The small size and comparatively simple structure of most syllidians no doubt peculiarly adapt them to this mode of multiplication. On account of its great advantage in the dissemination of the species, this form of reproduction, acquired by the presumably diminutive ancestors of the two gigantic species of Trypanosyllis, might be retained in a gradually modified form as by slow degrees the animal became larger and more complex. By equally slow degrees the collateral type of budding would replace the linear.[1] The development in both collaterally budding species of extensive intestinal diverticula (Fig. 16) in every somite from the proventriculus to the budding zone would obviously render inconvenient, if not impossible, the production of large gonads in the stock. As in many other syllidians the production of sexual cells would be more and more relegated to the most posterior somites, and to any linear or collateral buds that might develop in that region.

The advantages of collateral over linear budding in greater safety and compactness, as well as the possibility of securing a more rapid development and a greater number of buds, are obvious. Species of Myrianida produce stolons with the greatest number of zooids, but the chain is not known to have over thirty zooids at any one time.[2] This is only 60 per cent of the number of collateral buds present in the specimen of *Trypanosyllis gemmipara* that has been studied. The 50 buds of the latter add practically nothing to its length, while the 29 buds of the example of Myrianida figured by Malaquin form a chain no less than 55 per cent of the entire length of the worm. The liability to loss or injury to which such a

[1] In *T. zebra*, according to an observation recorded by Viguier in 1886 (*Arch. de Zool. Exp.*, sèr. 2, tome iv, p. 364, footnote), to which the author has kindly drawn my attention, there occurs an apparently non-terminal stolonization which perhaps is a step towards collateral budding. It is not well, however, to push the comparison very far, as there is really little likeness between the two types of gemmation as we know them at present.

[2] See Malaquin, *loc. cit.*, Pl. I.

lengthy chain would be exposed, particularly if very slender and attached to a stock of vastly greater bulk and strength, is evident.

The absence of organs of nutrition, the collateral mode of origin, and the fact that the smaller and simpler members of the genus still produce stolons point unmistakably to the high degree of specialization attained by the sexual zooids of these two species of Trypanosyllis. Both in their structure and in their mode of development they unquestionably represent the most specialized mode of asexual reproduction, not only among the Syllidæ, but among all known annelids.

THE COURSE OF THE BLOOD FLOW IN LUMBRICUS.[1]

J. B. JOHNSTON AND SARAH W. JOHNSON.

ALTHOUGH this form is almost universally used as a type for laboratory study, its circulation is still very imperfectly understood. The present contribution aims to give a better understanding of the course taken by the blood, as determined by observation and experiment upon large specimens of *Lumbricus terrestris*. The following brief review of the anatomy of the circulatory system, which is well understood, will serve as a basis for the discussion of the blood flow.

A large *dorsal vessel* extends along the dorsal surface of the intestine from the caudal end of the worm to the pharynx, over which it ramifies. Strong pulsations of this vessel run in more or less regular succession from the posterior to the anterior end. In somites VII to XI, inclusive, five pairs of circular vessels, the strongly pulsating *hearts*, encircle the œsophagus, connecting the dorsal vessel with the *ventral*. The ventral is a longitudinal trunk lying beneath the intestine and giving branches to the body wall and the nephridia. A *subneural* and two *lateral neural* vessels constitute, by reason of an irregular network of anastomoses between them, a connected system accompanying the nerve cord. This system is connected through branches of the lateral neurals with the body wall.

Connecting the dorsal and subneural vessels are the so-called *parietals*. They occur, one pair in each segment beginning with XII, close behind the septa and give off branches to the body wall and the nephridia. The parietal in somite XII is much larger than the others. In each somite two or more unpaired *ventro-intestinal* vessels enter the wall of the intestine from the ventral vessel, while two pairs of *dorso-intestinals* pass from the dorsal vessel into the wall of the intestine.

[1] From the Zoölogical Laboratory of West Virginia University.

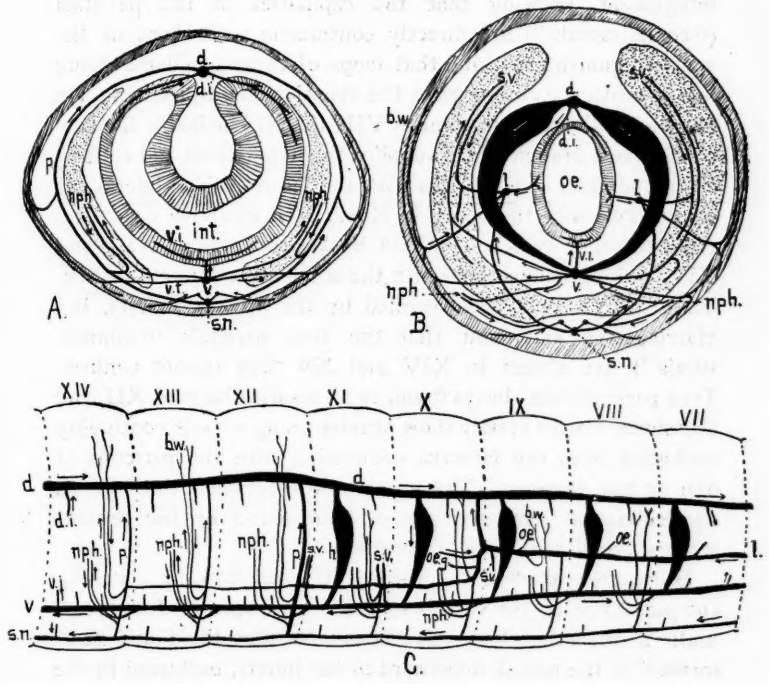
In somite X a pair of *lateral* vessels come from the dorsal vessel and run forward on either side of the œsophagus to the pharynx, giving branches to the œsophagus and body wall. An anastomosing vessel arises from the lateral near its origin in somite X and passes backward to join the large parietal in somite XII. From this anastomosis, branches supply the seminal vesicles, which are also supplied from the ventral vessel. Connecting vessels between the laterals and subneurals occur in several somites.

The only points with regard to the course of the blood flow upon which authors agree are that the blood flows forward in the dorsal vessel to the hearts, downward in the hearts, and backward in the ventral vessel. With regard to the further course of the blood Perrier came to the following conclusions (as reported by Bourne and Harrington): the blood flows into the dorsal vessel from the parietals and from it through the dorso-intestinals; the ventro-intestinals carry blood from the intestine to the ventral vessel; from the ventral it is given to the body wall and nephridia and is gathered up from these by branches from the lateral neurals and parietals; the flow in the laterals is forward.

Bourne ('91) studied the blood flow in Megascolex principally by holding the vessels with forceps and by cutting them to see from which cut end the blood flowed. His conclusions are nearly opposite to those of Perrier, namely, that the dorso-intestinals empty into the dorsal and the parietals carry blood away from it; the ventral gives blood to the intestine through the ventro-intestinals; it also gives blood to the body wall and nephridia, from which it is carried to the intestine (in Megascolex) by the intestino-tegumentaries. The lateral vessels carry blood backward.

Benham ('91), working on Lumbricus, agrees with Perrier in regard to the blood flow in all vessels.

Harrington ('99) has given a full account of the anatomy of the vascular system, with elaborate figures. His descriptions and figures, however, do not always agree, *e.g.*, the common vessel branching into ventro-tegumentary and ventro-intestinal described on page 142 is not shown in the figures. Harrington



DIAGRAMS TO ILLUSTRATE THE SCHEME OF CIRCULATION GIVEN IN THIS PAPER.

A, cross section of body region; *B*, cross section through hearts; *C*, sketch of vessels in somites VII to XIV seen from the side. Arrows indicate the direction of blood flow. *b.w.*, body wall and vessels supplying it; *d.*, dorsal vessel; *d.i.*, dorso-intestinals; *h.*, hearts; *int.*, intestine; *l.*, lateral vessel; *nph.*, nephridium and vessels supplying it; *œ.*, œsophagus and vessels supplying it; *œ.g.*, vessels supplying œsophageal glands; *p.*, parietals; *s.n.*, subneural; *s.v.*, seminal vesicles and vessels supplying them; *v.*, ventral vessel; *v.i.*, ventro-intestinals; *v.t.*, ventro-tegumentaries. The figures are unfortunately crowded, owing to the projection on one plane of many vessels which lie at different levels. The lateral neurals are not lettered in *A* and *B* and are not shown in *C*.

was the first to describe the arrangement of vessels to the integument, showing that the capillaries of the parietals ("commissurals") are directly continuous with those of the ventro-tegumentaries, and that loops of these capillaries lying just beneath the cuticle have the function of respiration. He has shown also that in somites VIII to XIII inclusive the subneural has a branch which supplies the nephridium and setigerous glands and anastomoses with the lateral. The lateral has connections with the dorsal in X and XII, as above described. Anastomosing vessels continue backward through XIII and XIV, making connections with the subneurals at each septum. These points have been verified by the present writers, but Harrington's statement that the true parietals ("commissurals") are absent in XIV and XV they cannot confirm. True parietals are always found in all somites back of XII, and occasional worms clearly show anastomosing vessels continuing backward from the laterals, connecting with the parietals of one or two somites. The anastomoses between the laterals and subneural have not always been found by the present writers in all the somites mentioned.

Harrington studied the course of blood flow by watching the pulsations of the vessels in small specimens of Lumbricus under a dissecting lens. He concludes that the blood flows forward in the dorsal, downward in the hearts, backward in the ventral, into the dorsal from the dorso-intestinals and out from it into the parietals ("commissurals"), forward in the laterals, and either forward or backward in the subneural.

The senior author has made observations on the course of the blood flow in connection with class work for a number of years. During this time the direction of flow in the subneural has been demonstrated in many student dissections, the result constantly agreeing with that stated below. The observations reported here have been made on the largest worms obtainable, anæsthetized and opened under physiological salt solution. The course of the flow in each vessel has been determined by the three methods of clamping, cutting the vessel, and watching the pulsations where these are visible. Injecting the dorsal vessel was tried several times, but as yet no facts

regarding the course of the flow have been made out by this means, although the injection gives a good demonstration of the anatomy of the vascular system.

Description of Experiments.

Many experiments give no definite results, owing to the condition of the worm or to violent disturbance of the circulation. Great care is required in recognizing and interpreting the results, especially in observing pulsations. It has been found that when fairly clear and definite results are obtained, the same result is given by the different methods.

1. *The Dorsal Vessel.* — The fact that the blood flows forward in the dorsal vessel up to the hearts is clearly shown by the course of the pulsations. In front of the hearts the pulsations are not conspicuous, and special attention was given to determining the course of flow in this part of the dorsal. Among the many worms dissected a few were found in which the pulsations of the dorsal were distinctly seen running forward to the pharynx. The dorsal vessel was clamped in front of the hearts in a number of worms, and in all cases the blood collected behind the clamp and disappeared in front of it. The blood flows forward throughout the whole length of the dorsal.

2. *The Ventral Vessel.* — The experiments noted below and the general agreement of authors make it certain that the blood flows backward in the ventral vessel back of the hearts. The course of the flow in front of the hearts was shown by clamping the ventral vessel in the seventh somite. In every case the blood collected behind the clamp and disappeared in front of it, indicating a forward flow.

3. *The Subneural and Lateral Neurals.* — The best results are obtained on these vessels by opening the worms from the ventral side. When the subneural vessel was cut the blood flowed only from the anterior cut end, *i.e.*, backward. The same result was obtained constantly by pinching the subneural with forceps: the blood collected very distinctly in front of the forceps and disappeared behind them. These experiments were tried in all regions of the worm.

4. *The Parietals.* — Clamping these vessels has given doubtful results. The first experiments were made by pinching them at about the middle of their length in a number of worms. The blood seemed to collect between the dorsal vessel and the forceps. More recently no results whatever have been obtained from the parietal vessels by this method. This is perhaps due to the fact that branches from the body wall enter the parietals both above and below the forceps. In each of eight worms a dozen or more parietal vessels were cut, and in every case in which bleeding occurred the blood flowed from the lower end, that is, toward the dorsal vessel.

Owing to the numerous connections of the parietal vessels, it is necessary to use indirect methods to determine the course of blood flow in them. In several sets of experiments the attempt was made to determine the source of supply to the parietals and their place of emptying, by clamping or cutting other vessels. All three longitudinal trunks, dorsal, ventral, and neural, were simultaneously clamped, with the following results in each case. The dorsal vessel was filled on both sides of the clamp. Although the pulsations were sometimes seriously interfered with, its normal fullness was maintained. This is to be explained, as will appear from what follows, by the fact that in front of the clamps a complete circulation is kept up and the fullness of the dorsal maintained by the dorso-intestinals and parietals *both* emptying into it. On the theory that the parietals and dorso-intestinals carry blood in opposite directions, it must be expected that the dorsal would be empty in front of the clamp in this experiment. If only one set of circular vessels empty into the dorsal, its own pulsations together with the other circular vessels must certainly drain it of blood in front of a clamp. Behind the clamp it is to be expected that the dorsal should be full, but the normal fullness is not greatly exceeded, because the clamping of the ventral and neurals cuts off the supply of blood to the posterior end of the worm. It is also possible that the course of flow is reversed in the parietals or dorso-intestinals or both, just behind a clamp on the dorsal, because of the excessive pressure developed by the pulsations of the latter vessel. In this

experiment the ventral and neural vessels were filled in front of, and empty behind, the clamps, indicating a backward flow in both. The parietals were filled both in front and behind the clamp. They were somewhat distended in front of the clamps, owing to increased pressure from the subneural in front of its clamp, while behind the clamps the parietals continued to collect some blood from the body wall and nephridia.

In four worms the ventro-intestinals in several segments were cut in order to drain the intestine of blood in those segments, and the dorsal was afterward clamped at both ends of the area in which the ventro-intestinals were cut. Between the clamps the dorsal decreased and the parietals were normally full. In four other worms the same result was reached when the dorsal was clamped in one place and the dorso-intestinals were cut for several segments in front of the clamp. Since the dorsal retained some blood and the parietals kept up their normal fullness as long as the worm lived, while all other supply to the dorsal was cut off, it is impossible to reach any other conclusion from these experiments than that the parietals bring blood to the dorsal.

Pulsations of the parietal vessels are not always clearly visible. In four worms in which the pulsations of the parietals were distinct and strong, a large number of these vessels were carefully studied. The contraction of the parietals occurs opposite the front part of the pulse wave of the dorsal, *i.e.*, while the dorsal is reaching its greatest fullness. The parietals fill just after the contraction of the dorsal, *i.e.*, opposite the point of constriction of the dorsal behind the pulse wave. The filling of the parietals is sudden and the contraction slow. This, taken together with the order of the contractions, indicates that the contraction of the parietals helps to swell the dorsal just in front of the constriction which carries its pulse wave along, while the rapid filling of the parietals is due to the sudden closure of the parieto-dorsal openings by the contraction wave of the dorsal. The results of all the experiments considered together strongly favor the conclusion that the parietals carry blood to the dorsal.

5. *The Dorso-Intestinals.* — When one clamp was put on the dorsal vessel and a number of parietals were cut just in front of it, the dorsal vessel only partly emptied; but when the dorso-intestinals in the same segments were cut the dorsal vessel emptied entirely. This and the experiments on the parietals described above, in which the cutting of the ventro-intestinals in one case and of the dorso-intestinals in another resulted in the decrease of the dorsal vessel in those segments, show that the dorso-intestinals carry blood to the dorsal.

6. *The Lateral Vessels.* — When the laterals are clamped either at both their connections with the dorsal in somites X and XII or in front of the connection in X, they remain full of blood, sometimes much distended, in front of the clamps. No vessels have given more positive and unmistakable results than these.

CRITICISM AND CONCLUSIONS.

There is no difference of opinion in regard to the blood flow in any part of the dorsal vessel. All authors agree that it flows forward to the extreme anterior end of the worm.

Bourne alone suggests that the blood flows forward from the hearts in the ventral vessel, since he considers that the strong contractions of the hearts would force blood forward as well as backward. Our experiments have confirmed this plausible view, and it may be regarded as proved that the blood flows forward in this part of the ventral.

Although previous workers have not agreed upon the functions of the parietals and dorso-intestinals, they all agree in assigning to these vessels opposite functions. The above experiments on the parietals, although not wholly decisive, give strong support to a different conclusion, namely, that both parietals and dorso-intestinals carry blood to the dorsal.

It follows necessarily that the ventro-intestinals supply the intestine with blood, as Bourne and Harrington contend.

According to Harrington's interpretation all of the blood in circulation would have to pass through the ventro-intestinals; in other words, all of the blood which is carried forward by the dorsal and all that which passes downward from the dorsal in

each somite through the parietals must be carried to the dorsal by the ventro- and dorso-intestinals. It does not seem possible for all of the blood to take this course, owing to the small size of the intestinal vessels. It has been impossible for the present writers to arrive at a definite conception of the blood flow according to Harrington's scheme. He represents the blood as flowing in different directions in different parts of the same vessel, and as changing its direction in the same vessel from time to time. Our experiments give no confirmation whatever to either of these conclusions, except that the direction is permanently reversed in the front end of the ventral vessel and in the dorso-intestinals in front of the hearts as above described. Temporary reversal of the flow in limited regions might easily occur as a result of the animal's movements, and such phenomena may have led Harrington to erroneous conclusions, since he worked only by studying the pulsations through the skin with a hand lens. His scheme of the circulation is full of inconsistencies, due either to an attempt to avoid overloading small vessels and consequent breakdown of the scheme, or to the incomplete study of several genera, resulting in a patchwork which is not true for Lumbricus at least. It is but proper to say that these inconsistencies might have been removed had the author lived to see his work through the press.

Bourne states that the lateral vessels carry blood backward, Harrington that they carry it forward. Our results positively support Bourne's view and, together with the results on the parietals, suggest a new interpretation of the morphology of the lateral vessels. Bourne considers them to be the subneural ends of the parietals in this region, *but assigns to them an opposite function.* The following facts seem to show that the lateral vessels are formed by anastomoses between successive parietals, which carry the blood from the head region to the dorsal in somites X and XII, and that the lateral system therefore represents the parietals in the head.

1. Absence of true parietals in front of somite XII.

2. Connections of the laterals with the subneural in several somites (VIII–XIII) which correspond perfectly to the ventral

ends of parietals, having branches to the nephridia as the parietals do.

3. Connections of the laterals with the dorsal in somites X and XII, corresponding to the dorsal ends of parietals.

4. Anastomoses between the parietals of somites XII, XIII, and XIV, in apparent continuation of the laterals.

5. Presence of branches of laterals to the body wall along the septa, corresponding to respiratory branches of the parietals.

6. Presence of branches to the seminal vesicles, which are also supplied by branches from the ventral. Here, as elsewhere, branches of the parietals take up blood which is brought from the ventral. The parietals are in the best position to supply the vesicles which are developed from the septa.

The origin of the hearts and laterals and the position of the laterals within the circular hearts are problems which require more facts for their solution. An extended discussion of them is beyond the province of this paper, but one or two suggestions will be made. The suggestion of Harrington that the hearts are modified parietals is negatived by the presence of both parietals and hearts in somite X, and by the different ventral connections of the parietals and hearts. It seems more probable that the hearts are enlarged circular intestinal vessels, serving to carry the blood brought forward by the dorsal. The lateral vessels must have arisen as anastomoses between successive parietals serving to return the blood from the head (brought forward by both dorsal and ventral), to the dorsal behind the hearts. The dorsal connections of the parietals in front of the hearts have disappeared from disuse. The position of these anastomoses within the circular hearts seems to indicate that they, too, have been derived from the capillaries of the œsophageal wall, although later than the hearts. This suggestion would explain the branches of the lateral vessels to the œsophagus and hearts, which otherwise are unexplained.

Conclusions. — The course of the circulation in each segment behind the hearts is as follows: the branches of the lateral neurals and parietals collect blood from the body wall; the parietals take blood to the dorsal from the subneural, body

wall, and nephridia; the dorso-intestinals give blood to the dorsal from the intestine; all of this blood goes forward in the dorsal to the hearts; through them nearly all of it is given to the ventral vessel, which sends it to the intestine through the ventro-intestinals and to the body wall through the ventro-tegumentaries.

The head region is supplied with blood by the dorsal and ventral vessels, and the neurals and laterals carry blood from it.

The dorsal and ventral vessels carry mixed blood, the dorsal receiving oxygenated blood from the parietals and non-oxygenated from the dorso-intestinals. The neurals carry oxygenated blood only. The dorsal and ventral vessels carry mixed blood to the head region; the laterals carry backward mixed blood, and the neurals oxygenated blood.

There is no support given by our experiments to the idea of a more or less complete segmental circulation in Lumbricus. The circulation is strictly systematic, the blood making a complete circuit from the hearts backward through a greater or less number of somites, upward through the body wall, nephridia, or intestinal wall, to the dorsal, and thence forward to the hearts. This scheme of circulation is simple, and the slight modifications of it, which occur in the head region only, have received at least an attempt at explanation above. The interesting and highly important question presents itself: What happens when a worm's head is cut off and it lives and regenerates a new head, or perchance a tail? With the removal of the hearts some substitute must be provided to carry the blood from the dorsal to the ventral vessel. A series of regeneration experiments have been begun to find the answer to this question.

October 23, 1901.

LIST OF PAPERS CITED.

PERRIER (reported by Bourne and Harrington).

'91. BENHAM, W. B. The Nephridium of Lumbricus and its Blood Supply. *Quart. Journ. Micr. Sci.* Vol. xxxii, p. 293.

'91. BOURNE, A. C. On Megascolex cœruleus and a Theory of the Course of the Blood in Earthworms. *Quart. Journ. Micr. Sci.* Vol. xxxii, p. 49.

'99. HARRINGTON, N. R. The Calciferous Glands of the Earthworm, with Appendix on the Circulation. *Journ. of Morph.* Vol. xv, Supplement, p. 105.

NOTES AND LITERATURE.

GENERAL BIOLOGY.

Organic Regulations. — Hans Driesch publishes, under the title of *Die organischen Regulationen*,[1] a pamphlet of 228 pages which deals with a number of organic phenomena, some of which are better known as adaptations, others as restitution of form and of function. The subordinate title of the paper, "Vorbereitungen zu einer Theorie des Lebens," indicates the ambitious aim of the author.

The contents are arranged under three headings: I, Descriptive Part; II, Theoretical Part; III, Critique of Knowledge.

I. In the first part we find a description given of metabolic regulations (adaptations), of morphological adjustments to the environment, and of restitution or restorative regulative processes. An attempt is made to sift out the essential features of these phenomena.

II. In the theoretical part the different kinds of regulations are classified, the relation between regulations and stimuli is discussed, and an analysis of form regulation is attempted. Under this same heading a section is entitled "Thoughts on Respiration and Assimilation." Here an hypothesis of the "real" meaning of the process of oxidation in organisms is suggested, and a curious inquiry is made into the fundamental but almost unknown field of assimilation. Then follow two "proofs" of vitalism, or, as the author prefers to call the latter, "The Autonomy of the Life-Processes."

The first proof of the autonomy of the life process is an extension of the same argument previously employed by Driesch, and deals with "The Differentiation of Harmonic Equipotential-Systems," or, more simply, with the formation of a new whole organism from a piece of an egg or from a piece of an original organism, — the piece having in both cases the potencies of the original whole in all its parts.

The second proof of vitalism is found in "The Genesis and Existence of Equipotential Systems with Complex Explicit Potencies." The author believes "it is impossible that a complicated structure (*Tektonic*) made up of many definitely arranged parts (*Specifitäten*)

[1] Driesch, Hans. *Die organischen Regulationen:* Vorbereitungen zu einer Theorie des Lebens. Leipzig, W. Engelmann, 1901. 228 pp.

differentiated in three dimensions could divide itself by material means into the elements of an equipotential system." "If each organism produced but one egg, then the materialistic conception of heredity might be true, in which case there need not be of course a regulative restitution; but since the organism produces many eggs, the conception is impossible; because, (I), in order that the developmental phenomena may be deduced materialistically they must be thought of under the assumption of a complicated primary machine, but, (II), on account of the required division of the complex potencies into the elements this assumption cannot be made."

Perhaps these statements may be clearer in the following quotation, in which both the first and the second proofs of the autonomy of the life process are considered together. "The preceding phenomena can be interpreted only on the basis of machines of a complicated sort — but such machines can, for other reasons, not exist. They cannot exist, in the first place, because a machine does not remain the same when we take away any of its parts, or when we rearrange its parts; for machines do not possess the property of division." It can scarcely be claimed by the author that the discovery that organisms are not machines is new, but having admitted this, it does not seem to follow that, therefore, there must be a vitalistic principle in nature. There seems to us to be a great hiatus in Driesch's argument, and in any case his conclusions appear to be based rather on our ignorance of what the organism really is than on a demonstration that it is something that cannot be conceived under a causal-mechanical point of view.

III. In the final section of the paper a number of philosophical and metaphysical topics are discussed, and the author defines his position in regard to the use and meaning of the terms "mechanism" and "causality."

ZOÖLOGY.

Fauna of Switzerland. — The origin of the present fauna of Switzerland from that of the glacial period has been the subject of repeated investigations, but these studies were mainly restricted to the higher forms of terrestrial life. A recent publication by Prof. F. Zschokke[1] not only gives a condensed review of our knowledge

[1] Zschokke, F. *Die Tierwelt der Schweiz in ihren Beziehungen zur Eiszeit.* Basel, 1901.

of the origin of the Helvetian fauna in general, but preëminently applies the views gained by previous studies to the lower forms of animals that inhabit the fresh-water lakes, streams, etc., of the country.

Professor Zschokke points out that the present terrestrial fauna and the present flora belonging to the high mountain regions of the Alps find a counterpart in the arctic regions, the identical species being in many cases represented there. These two main ranges are in some degree connected by intermediate, but isolated and discontinuous, stations on the highest elevations of the intervening low countries, or in localities which, owing to local conditions, possess a particularly cool climate (for instance, peat bogs). It is generally agreed that this peculiar distribution is to be explained as a remnant of the glacial period. During the latter the originally alpine and arctic fauna and flora was widely distributed over the low countries of central Europe, where it found congenial climatic conditions. After the close of the glacial period, at the commencement of a warmer climate, this glacial fauna and flora retreated in two directions: toward the north pole, and toward the high mountains to the south; while in the intervening parts it remained only in a few scattered colder localities, such as the highest summits of the mountains of central Germany. The parts evacuated by this arctic element were occupied by a new stock of life that immigrated chiefly from the east (Siberia).

This is true for plants and terrestrial animals, such as mammals, land mollusks, insects, reptiles; and in many cases we have direct means of ascertaining and verifying this process, since we know glacial and interglacial remains of the respective forms that have been found in the low parts of central Europe.

While it thus seems positively assured, by paleontological facts, that the origin of the alpine flora and terrestrial fauna of Switzerland is to be traced back to glacial times, and lies in the vast country bordering the ice sheet that covered north Europe to the south, we have no such evidence as regards the fresh-water fauna. Nevertheless, Professor Zschokke demonstrates that the distribution of many fresh-water animals of the alpine lakes and streams of Switzerland exhibits the identical peculiar features that are known in terrestrial animals; they reappear in arctic fresh-water basins offering the same climatic conditions, and are wanting in the intermediate tracts except for a few scattered and exceptionally favorable localities. From this similarity in distribution we are to infer that the origin of the distribution of these fresh-water forms was subject to the same laws.

But there is an important difference of the fresh-water fauna from the terrestrial. In the latter, the different faunas, the old glacial and the newer postglacial, are, in the mountains, so to speak, on top of one another, the postglacial fauna occupying the lower parts and ascending the mountains only to a certain elevation, where it gives room to the older fauna, which has taken to the summits. In the fresh-water fauna, however, there is a much larger degree of intermingling; indeed, the postglacial immigrants have been able to reach the most exposed and highest stations in the mountains, and are found everywhere in close vicinity and association with the older glacial elements. According to Zschokke, this fact is due, on the one hand, to the character of the immigrants, which are cosmopolitan, eurytherm forms of life, which may find congenial conditions of existence anywhere; on the other hand, it is due to the peculiarities of temperature in the fresh-water bodies, where the extremes are not so much contrasted and lie closer together than those of the air influencing the terrestrial animals.

The old glacial fauna of the glacial time did not only retreat in these two directions mentioned, but there is a third *refugium* for those that belong to the fresh water. In the depths of the great lakes that fringe the northern foot of the Alps, similar conditions of temperature prevail as in glacial times everywhere in fresh water. These cold depths contain a fauna consisting of peculiar fishes (Salmonidæ) and crustaceans (the latter chiefly pelagic) that point distinctly to a northern origin. These forms apparently immigrated at the close of the glacial period, when there was an abundance of cold water derived from the receding ice. Later, after the abundant supply of water had given out, these forms were cut off from the communication with their northern homes, and their only chance to survive was in these large and cold fresh-water lakes, which resemble their original home at least in temperature.

Thus we may distinguish, among the fresh-water fauna of Switzerland as well as among the terrestrial fauna, two elements: (1) an old glacial stock that lived during the glacial period all over the inhabitable parts of central Europe; and (2) a later immigration in postglacial times. The first one retreated out of the plains in two directions: toward the north pole and toward the mountains. But while for the terrestrial animals which fled to the highlands no other way was left than to go upward, for some of the fresh-water animals a third asylum was open: the deep and cold fresh-water lakes on the northern border of the Alps.

A. E. O.

North American Finches.[1] — This work, when complete, will of course be the standard book of reference on North American birds. It represents the matured views of our foremost ornithologist and is remarkable for the clear and terse, yet ample, manner in which the facts are presented. It includes not merely the birds of the United States and Canada, but also those of Central America, Mexico, the West Indies, and the Galapagos Islands. A full bibliography is given for every species and subspecies; and there are numerous measurements of specimens from different localities, indicating slightly variant forms not designated by special names.

The present volume includes the sparrows and finches. Excluding the Galapagos genera, and three species introduced from Europe, we have 186 species, to which are added 165 subspecies, making 351 named forms in all. The species may be divided thus:

1. Monotypic species in monotypic genera . . . . . 13.
2. Polytypic species in monotypic genera . . . . . 8.
3. Monotypic species in polytypic genera . . . . . 106.
4. Polytypic species in polytypic genera . . . . . 59.

Total monotypic species, 119; polytypic species, 67.

A monotypic genus is one which has only a single species; a monotypic species is one having only one form, *i.e.*, without subspecies.

The monotypic genera of the first group are distributed thus:

1. Great plains of North America: Rhynchophanes, Calamospiza, Centronyx.
2. Mountains of Western North America: Oreospiza.
3. Mexico and Central America: Plagiospiza, Pselliophorus, Pezopetes, Acanthidops, Rhodothraupis.
4. Cocos I., off Bay of Panama: Cocornis.
5. West Indies: Melanospiza (St. Lucia), Loxipasser (Jamaica), Loximitris (Haiti).

It is significant and interesting that there are no monotypic genera with monotypic species east of the great plains; or, excepting Oreospiza, west of them to the Pacific. The conditions in the west, which have produced so many distinct species and subspecies, have not yet given us, in the groups under consideration, new generic types. In other words, the evolution of the peculiar western genera antedates the comparatively recent development of local specific forms. This agrees very well with the results obtained from the study of other groups, *e.g.*, the flowering plants. We find numerous closely allied

[1] Ridgway, Robert. The Birds of North and Middle America, Part I, *Bull. No. 50. U.S. Nat. Mus.*, 1901. 715 pp., 20 pls.

species belonging to old and widespread genera, pointing to a recent period of plasticity of types, not going so far, however, as to affect the genera. For the development of new genera, environmental conditions of great stability and complexity, such as exist to-day in the tropics, seem to be most favorable; and it may very well be that most of the distinctive North American genera had their origin at a time long previous to the glacial period, when such conditions more nearly prevailed on this continent. The changeable conditions of recent periods, while extremely favorable to the production of new subspecies or even species, might from their very instability be inimical to the development of new genera.

It is interesting to observe how much more plastic some species are than others. Thus, in the genus Melospiza, *M. lincolnii* and *M. georgiana*, though very widespread, remain monotypic, while *M. cinerea* has split up into no less than twenty-one subspecific forms, many of very restricted distribution.

A very interesting discussion is given of the Galapagos genus Geospiza. This includes twenty-seven forms, the extremes of which are so distinct that they used to be assigned to different genera; yet the gradation from one to the other is almost complete. Messrs. Rothschild and Hartert proposed to regard a number of these forms as subspecies of the others; but Mr. Ridgway urges that there is really no alternative between regarding them all as forms of one species and treating them all as specific units. Since the former course is one that would commend itself to no one, the latter is adopted, with the result that we have a series of "species" far more intimately related than the forms usually classed in this category. We feel much as we might feel if suddenly confronted with the whole series of extinct types connecting our very "good" genera and species of the present day. Were the Galapagos less isolated, and the competition with other groups of birds more severe, no doubt several of the links would be conveniently missing by this time, and we should not have occasion to dispute over the status of the remainder.

Many endemic forms are recorded from the islands of the California coast and the West Indies. These are in most cases regarded as subspecies only; though, in the inevitable absence of intermediate series occupying the intervening territory (this being water), it would seem more logical to treat them as distinct species. We seem to need a new term to express these allied insular forms; but since their continuity with the parent species is assuredly broken, I would rather write

the names as binomials; *e.g.*, *Pyrrhulagra ridgwayi* for *P. noctis ridgwayi* Cory; *Melospiza graminea* for *M. cinerea graminea* (Townsend).

A very singular case is that of *Euetheia bicolor omissa*, occupying most of the West Indian Islands, but replaced in Jamaica, Haiti, Barbados, and Grenada by *E. b. marchii*. Are we to suppose that the latter once occupied the whole chain of islands but has given way to the former wherever it appeared upon the scene?

Two statements in the work seem to call for special comment. One is as follows: "The necessity for beginning this work with the highest instead of the lowest forms is to be regretted, and may be explained by briefly stating that owing to inadequate facilities for properly arranging the larger birds in the National Museum collection these are not available for study, and consequently it became necessary either to begin with the smaller birds, already systematically arranged, or else postpone the work indefinitely."

That such a statement should be made regarding our National Museum may well make us feel ashamed. Is this country too poor to provide facilities for such a man as Mr. Ridgway, who returns to it a thousandfold the small means it has placed at his disposal? Are we so blind that we cannot see that scientific knowledge is more than the equivalent of money; is not merely convertible into that medium, but is in itself far more nearly an end of national existence, since it adds to the worth of the individual himself, and not merely to the worth of that which is temporarily attached to him?

The other statement referred to is quite different. We are told: "There are two essentially different kinds of ornithology: *systematic*, or *scientific*, and *popular*. The former deals with the structure and classification of birds, their synonymies and technical descriptions. The latter treats of their habits, songs, nesting, and other facts pertaining to their life-histories." The present writer has to confess that this statement quite took his breath away. The study of living birds, then, is "popular," but the study of their mortal remains, stuffed with cotton and provided with tags, or occasionally, perhaps, immersed in alcohol, — this is "scientific." It is hardly possible that Mr. Ridgway could have intended his words to be taken literally. No one could deny that Mr. Ridgway's work on museum material is in the highest degree scientific, and we may freely admit that nine-tenths of what is written on the habits, nesting, etc., of birds is much less so; but it surely does not follow that the story of life histories is in the least degree less scientific, in itself, than any other branch of ornithology. One might as well say that the study of alcoholic

brains is scientific (because the literature of that subject is so), but the study of mental processes is popular, or non-scientific, for the reason that we have a mass of trivial literature on psychology.

T. D. A. C.

Notes on Fishes. — In a recent visit to San Diego the writer saw in the possession of an animal artist, Miss Annie Andrews, good paintings of the threadfin, *Polydactylus approximans*, and the sea bonito, *Gymnosarda pelamis*. The threadfin is common about Mazatlan, but had never been taken in the limits of the United States. It was once described as *Polynemus californiensis* by Thominot, from "California"; but that California which stretches from Rogue River to Cape San Lucas is zoölogically very indefinite, comprising three distinct marine faunas. The oceanic bonito is common at Honolulu and in Japan, and was once before noticed by Eigenmann at San Diego.

In the *Scientific American* for December 21 Mr. C. F. Holder publishes a photograph of *Luvarus imperialis*, a large and rare fish of the Mediterranean, lately taken at Avalon on Santa Catalina Island, off the coast of California. There is no question as to the identity of the species with the genus Luvarus, and no specific difference appears in Mr. Holder's photograph, a copy of which the writer has seen.

Mr. Holder also reports that he has seen two specimens of the oarfish, *Regalecus (russelli?)*, taken in Avalon Bay. One of these, two feet long, was examined by him while alive. "Its topknot," Mr. Holder says, "was a vivid or scarlet mass of plumes. The dorsal spines, which merged into a long dorsal fin, extended to the tail. The color of the body was a brilliant silver sheen, splashed with equally vivid black zebra-like stripes." Mr. Holder was unable to obtain either specimen, the finders insisting on placing them on a piece of board to be dried in the sun as "curios." In this condition the water soon evaporated, and practically nothing was left.

In *Science* for Dec. 13, 1901, Gill and Townsend give an account of a large fish about five feet in length, dredged by the *Albatross* at a depth of 1050 fathoms off the Chonos Archipelago in Chile. By some accident the huge specimen was cast overboard, and the description is made from a photograph. The fish is of trachinoid affinities and is perhaps one of the Percophidæ. The name given it is *Macrias amissus*. The recent explorations of Dollo show that

in the deep seas of the Antarctic, as well as the shore waters, trachinoid fishes related to Percophis and Notothenia are numerous and characteristic.

In the *Proceedings of the New England Zoölogical Club*, Mr. Samuel Garman shows that the Japanese deep-water Chimæra described by Professor Mitsikuri as *Harriotta pacifica* is the type of a new and still more primitive genus, which he calls Rhinochimæra. It differs from Harriotta by the possession of teeth like the horny covers of the jaws on tortoises and birds, without the separate tritors found in Chimæra, Harriotta, and Callorhynchus. Garman divides the group into three families, Chimæridæ, Callorhynchidæ, and Rhinochimæridæ, the latter including Harriotta. Garman makes the important discovery that the frontal holder or cartilaginous hook on the forehead of the male is present on the adult of Harriotta and Rhinochimæra as well as on Chimæra and Callorhynchus. As with the ventral claspers, this is developed only when the animal is sexually mature. Its presence is therefore a distinctive character of all the living Chimæra-like fishes, and it is found in no other fishes. Mr. Garman's paper, though brief and not illustrated, is a most valuable addition to our knowledge of these fishes.

Under the head of "The Smallest Known Vertebrate," Dr. H. M. Smith gives in *Science* for Jan. 3, 1902, an account of a diminutive goby only fifteen millimeters long when adult, found in Lake Buki in southern Luzon, where, from its great numbers, it is an article of food of considerable importance. It is named *Mistichthys luzonius*. The genus is very close to the Japanese Eutæniichthys, also very diminutive, but it has larger and rougher scales than the latter.

In the *Bulletin of the Museum of Paris* for 1901, Dr. Pellegrin notes a collection of fishes obtained by M. Diguet in the Lake of Chapala and in Rio Lerma in Mexico. Most of the species have been already noted by Jordan and Snyder. One new species, *Xenendum multipunctatum*, is described from the pond called Agua Azul, near Guadalajara. I cannot agree with Dr. Pellegrin that *Ameiurus dugesi* of Lake Chapala is the same as *Ameiurus catus*, nor that the little *Gambusia infans* is the same as *G. affinis*.

Under the head of "Les Poissons Vénéneux," Dr. Jacques Pellegrin of the Museum at Paris publishes a valuable account of the fishes of which the flesh is known or suspected to be poisonous. It appears that in Tetraodon, Spheroides, Tropidichthys, Balistes, Monacanthus, and other genera — mostly globefishes, filefishes, and

trigger fishes — a poisonous alkaloid is developed which causes a very dangerous disease known in Cuba as ciguatera. This poison attacks the nervous system, and through it other organs, often producing death. Similar alkaloids of less virulence exist in sharks and some other fishes. Dr. Pellegrin regards it as a kind of device for the preservation of the species by the destruction of its enemies with the death of the individual. The virulence of the poison is less in fresh waters and grows less away from the tropics.

Similar effects are sometimes produced by the flesh of species otherwise innocuous which have been themselves poisoned by poisonous mollusks, polyps, or fish.

Illness caused by decayed fish flesh or by undigested fish has no relation to ciguatera. This Pellegrin calls "ichthyosisme," and it may be produced by various species under conditions adverse to assimilation.

In a monthly publication called *Japan and America*, for January, 1902, Dr. Jordan gives an account of the Salmonidæ of Japan, this paper being an epitome of one sent to Japan for publication. The valid species known in Japanese waters are the Sake (*Oncorhynchus keta*), the Ginmasu (*Oncorhynchus kisutch*), the Yesomasu (*Oncorhynchus masou* or *O. yessoënsis*, accidentally omitted in this paper), the Benimasu (*Oncorhynchus nerka*), the Yamabe or Kawamasu (*Salmo perryi*), the Ito (*Hucho blackistoni*), the Iwana (*Salvelinus pluvius*), the Malma (*Salvelinus malma*), the Amemasu (*Salvelinus kundscha*), and the famous Ayu, one of the finest food fishes in all the world (*Plecoglossus altivelis*). This dwarf salmon of the rivers should by all means be introduced into the clear streams of Maine, Quebec, and California. Few finer food fishes exist anywhere. D. S. J.

Vascular System of Bdellostoma dombeyi. — C. M. Jackson[1] has made the vascular system of *Bdellostoma dombeyi* the subject of investigation. The author emphasizes the interest and importance attaching to the Cyclostomata owing to their being the lowest of the Craniata and possessing many structural features which must be regarded as ancestral. The blood-vascular system is described in detail, and certain points concerning its comparative anatomy are discussed.

The heart is a simple tubular organ, situated in a pericardial chamber which retains free communication with the peritoneal

[1] Jackson, C. M. An Investigation of the Vascular System of Bdellostoma dombeyi, *Journ. of the Cin. Soc. of Nat. Hist.*, vol. xx, No. 1, pp. 13–48. 3 pls.

cavity. There may be as many as fourteen pairs of functional branchial vessels, all the efferent branchial arteries on each side being connected by a longitudinal commissural vessel which continues forward as the common carotid of that side. The dorsal aorta extends forward into the head region. An inferior jugular vein is present, and there is a persistent subintestinal vein which does not join the portal system. These characters are among those which the author regards as primitive. There is a portal heart whose walls contain distinctly striated muscle fibers. The contractility of the portal heart is included among the primitive characters.

The following features the author considers to have been secondarily acquired. The venous system is asymmetrical. The branchial vessels distribute "to gill slits instead of gill arches." The portal system receives blood from the anterior body region. The caudal vein connects with the posterior cardinals. The portal heart has well-developed valves.

H. W. R.

On Hair in the Equidæ. — F. H. A. Marshall[1] discusses the hair of Equidæ with special reference to peculiarities which, he believes, are of taxonomic importance. The chief characters which he finds to be of specific value are the shape and size, the extent of development of the medulla, the relative thickness of cortex and medulla, and the distribution and arrangement of pigment in the cortex. The cuticle exhibits only slight modifications in the several members of the group.

Much greater variability in the character of the hairs was found in *Equus caballus* than in the zebras. The hairs of zebra-horse hybrids show surprisingly little variation, even though the dams were of various breeds. The hybrid hairs resemble closely those of the zebra sire.

No evidence was found, so far as hair was concerned, in support of the telegony hypothesis.

H. W. R.

Notes. — Wesley R. Coe describes the nemerteans collected by the United States Fish Commission steamer *Fish Hawk*, at Porto Rico, in the summer of 1899 (*Bulletin United States Fish Commission*, 1900, Vol. II, pp. 223–229). Eight species are represented among the very few individuals collected. At least three of the species are new. The collections of Professor Verrill, at Bermuda, and Ehrhardt, at Barbados, exhibit the same marked scarcity of nemerteans.

[1] *Proc. Royal Soc. Edinburgh*, vol. xxiii, pp. 375–390. 6 pls.

An isopod parasitic on the small hermit crabs found in the vicinity of Woods Hole is described by Millett T. Thompson (*Bulletin United States Fish Commission*, 1901, pp. 53–56, Pls. IX, X). The female parasite is found on the abdomen of the host, the comparatively small male being attached to the marsupium of the female. The isopod, probably representing a new genus allied to *Phryxus resupinatus* Müller, has been named *Stegophryxus hyptius*, the generic name being given in reference to the covering of the female, as it lies upon the host, by its marsupium.

Prof. Carl H. Eigenmann reports on his investigations into the history of the young squeteague of Buzzards Bay and Narragansett Bay (*Bulletin United States Fish Commission*, 1901, pp. 45–51). The young fish are pelagic in habit, subsisting entirely upon shrimp and smaller fish. The report considers further the distribution of the young squeteague, their rate of growth, and the changes accompanying growth, in body proportions and coloration.

Captain Tuttle of the revenue cutter *Bear* has presented to the Museum of Stanford University a pair of native boots which he brought back from a recent visit to the north, and which were made by a native on St. Lawrence Island in the Bering Sea from the skin of a half-grown bull fur seal, taken in the winter of 1900 in the ice adjacent to the island. St. Lawrence Island is 500 miles to the northward of the Pribilof Islands, and it is interesting to note that this is the first time the fur seal has been taken at any considerable distance north of the Pribilof group.

BOTANY.

De Bary's Bacteria. — The wisdom of a third edition of de Bary's *Vorlesungen über Bakterien*[1] so long after the death of its author may well be questioned. New discoveries on every hand have revolutionized old views, and to properly revise such a work would require it to be doubled in size and practically rewritten. This Dr. Migula has carefully refrained from doing. The title-page reads, "Dritte Auflage durchgesehen und teilweise neu bearbeitet von W. Migula," and in the preface apologies are offered for lack

[1] De Bary, A. *Vorlesungen über Bakterien*. Leipzig, Wilhelm Engelmann, 1900.

of thoroughness on the ground of respect for the memory of the author and for fear of disturbing the form or framework of the book. Changes have been made only "wo sich eine absolut zwingende Notwendigkeit ergab." De Bary, who loved thoroughness so well, would never himself have consented to such a thing. It is safe to say that the book will not please either the reviser or the readers. It is at least questionable whether it is ever wise to revise a book after an author's death, especially when very extensive changes will be necessary to bring it up to date, and in this case it is quite certain that Dr. Migula would have done much better to have written an altogether new book. The first edition of de Bary's *Vorlesungen über Bakterien*, published in 1885, contained 18 woodcuts and 146 pages of text. The new edition contains 41 figures and 186 pages of text. Three new chapters are added dealing with sulphur bacteria, nitrogen bacteria, and the question of immunity, toxins, antitoxins, toxalbumins, etc. The book is about the size of Fischer's *Vorlesungen* and will find a place beside it on the library shelf. It compares very favorably with Fischer's book, but, as in the case of the latter work, the least well-made part of the compilation is that relating to plant diseases. Four diseases only are noticed, and no contribution more modern than Kramer's wet rot of the potato, published in 1892, finds mention. In case of Wakker's hyacinth disease, de Bary's statement that "successful infections and an exact following of the life history of the bacterium are still wanting" is repeated. Under "pear blight," the long exploded statement that the organism produces carbon dioxide, hydrogen, and butyric acid is once more repeated. Under Kramer's "wet rot of the potato," it is thought to be safe to hint that there may possibly be other bacteria capable of producing similar phenomena. Of general statements, the following sufficiently indicate the value of this résumé: "The firm cell membrane of the plant cell is an almost insurmountable obstacle to the bacteria, especially as the very great majority of the bacteria are not able to attack cellulose. It is true that in recent years especially there have been described very many so-called "bacterioses," that is, diseases in plants caused by bacteria, but only a few will stand searching criticism. . . . In the great majority, bacteria are certainly not the cause. . . . Considering the uncertainty and inadmissibility of most of the accounts relative to bacterioses, there is no necessity of inquiring further about diseases which presumably will sooner or later be stricken out of the list of the bacterioses."

All of which means that to be a safe guide a man must actually have done something in the particular field which he undertakes to summarize. The book is well made and attractive in appearance.

E. F. S.

A New Elementary Text-Book. — A clear indication of the broadened scope of botanical instruction is afforded by the discarding of class books which only a decade or two ago were sufficient for the purposes of the ordinary teacher. The books that have replaced them are not only very different from their predecessors but from one another. Some are questionably the equals in any respect of those that are dropping out; others, though they have the merit of giving a broadened view of the subject, overshoot the classes they are intended for; still others are as one-sided on a new phase of the science as the older ones were on another.

As long as there is individuality in teachers, universal satisfaction is hardly to be expected from any text-book, and as questions of temperance and cruelty have not yet intruded themselves into the botany of secondary schools, it is probable that individuality in its teachers may long resist the tendency to mechanical uniformity to which many forces contribute with considerable persistency. With any book, however much the teacher may desire to avoid giving the impression that all desirable knowledge is contained between its covers, it is difficult to prevent many pupils from at least tacitly holding this opinion, and good as many of the recent books are, it is to be feared that their use is causing some of the wholesome everyday knowledge of one's dooryard plants of a generation ago to be replaced by a broader and doubtless more scientific, but unfortunately less practically tangible knowledge of vegetation in the abstract.

To meet the undoubted need of a more comprehensive work than Dr. Gray's *Lessons* without losing the advantage of its rational point of view, excellent spirit, and good handling, Mr. Leavitt, at the request of the botanical department of Harvard University, has based on it a little book[1] which appears admirably adapted to the class room, and which, by the introduction of a series of well-devised and simple exercises, makes possible that most desirable of evolutions, — the conversion of the recitation room into a laboratory.

T.

[1] Leavitt, R. G. *Outlines of Botany for the High School Laboratory and Class-Room.* Based on Gray's *Lessons in Botany.* American Book Company. 272 pp., 383 figs.

Notes. — Mr. Gandoger has turned his discriminating eye on the North American representatives of Astragalus and Oxytropis, and in the number of the *Bulletin de la Société Botanique de France* of January 5 he adds a considerable number to their named species, varieties, and forms.

A Rhododendron related to *R. punctatum*, and from the Savannah River, Ga., is described under the name *R. cuthbertii*, by Dr. Small in *Torreya* for January.

In *Torreya* for January Mr. Howe extends the range of *Arceuthobium pusillum* to Nova Scotia and Newfoundland.

Three palms (*Ptychosperma elegans*, *Archontophœnix cunninghami*, and *A. Alexandræ*), commonly cultivated under the name *Seaforthia elegans*, are disentangled in the *Gardeners' Chronicle* of January 11, by Dammer, who illustrates the first and last named by reproductions of photographs taken in the Buitenzorg garden.

The species of Porphyra of the Pacific coast of North America are revised by Hus in Vol. II, No. 6, of the botanical section of *Proceedings of the California Academy of Sciences*, issued January 4.

Professor Peck's "Report of the State Botanist" for 1900, separately printed from the 54th *Report of the New York State Museum*, contains plates illustrating a large number of edible agarics.

Bulletin No. 3 of the Lloyd Library is the first number of a mycological series, and deals with the genera of Gastromycetes. Mr. C. G. Lloyd is the author. Forty-nine figures, mostly half tones, are used in illustration.

Miss Vail gives a readable history of Van der Donck and his seventeenth century New Amsterdam garden, in the *Journal of the New York Botanical Garden* for December.

In *Rhodora* for December, Miss Day concludes her annotated list of the herbaria of New England.

A short article on Lapham, whose herbarium is preserved at the University of Wisconsin, is contributed by his daughter to *The Wisconsin Archæologist* for January.

The *Journal of Botany* for December contains a good portrait of J. G. Baker.

In a neatly gotten-up but rather crudely illustrated booklet published by William Briggs of Toronto, and entitled *Sylvan Ontario*, Principal Muldrew of the Gravenhurst high school gives leaf keys to

the recognized trees and shrubs of his district. It is pleasing to read that the high school possesses an arboretum in which practically all of the species are cultivated.

The relation of forests to snow is discussed by Carpenter in *Bulletin No. 55 of the Colorado Experiment Station*, illustrated by a series of photograms from excellent negatives.

In paper, presswork, and general appearance the third annual report of the New York State College of Forestry, recently distributed, is more like a product of the British colonies than of the United States.

The value of growth rings in the so-called exogenous trunk, as an index of age, is considered by Roger in the *Revue Horticole* of January 1.

The distribution in Iowa of twenty native forest trees is discussed by Professor Bessey in *The Forester* for December.

The big trees of California are the subject of a well-illustrated article by R. T. Fisher in *The World's Work* for February, which also contains illustrated articles on the cultivation of tobacco under cloth in Connecticut and the growing of olives in California.

What the cedar of Lebanon may become in cultivation is shown by photograms in the *Gardeners' Chronicle* for January 4.

PETROGRAPHY.

Tillman's "Text-Book of Important Minerals and Rocks," [1] is an attempt to present to the student a brief account of the characteristics of the common minerals and rocks. The plan of the book is good. It discusses the elements of geometrical crystallography in 24 pages, in which only the most fundamental forms of the six systems are described. The physical and chemical properties of minerals are discussed in the next 5 pages. Then follow 65 pages devoted to the description of about seventy-five of the commonest mineral species, and about 40 pages in which the descriptive material is embodied in tabular form. The final 22 pages treat of the commonest rocks.

[1] Tillman, S. E. *A Text-book of Important Minerals and Rocks.* With tables for the determination of minerals. New York, John Wiley & Sons, 1900. 186 pp., 35 figs.

For an elementary treatise the book contains enough matter. The author unquestionably did well when he decided to limit his descriptions to seventy-five species and make them fairly full rather than to attempt to discuss a greater number and devote only a few lines to each. There is nothing to criticise unfavorably in the chapters on crystallography and on the physical and chemical properties of minerals. They are extremely brief, to be sure, but they are well arranged. Their topics are well chosen, and the statements in them are accurate. The tables are likewise good. They contain no peculiar features that need elucidation.

In the descriptive portion of the volume there is quite a little loose writing, which is especially to be condemned in a beginner's book. The order in which the minerals are taken up is that which seems to appeal to most writers of elementary treatises. It is not scientific, but it possesses the advantage of impressing on the student the economic importance of the different compounds. The important metals and their ores and compounds, other than the silicates, are treated together. Then come the silicates. The grouping of the latter follows no general scheme. The order in which they are discussed "is mainly intended to emphasize and fix in mind their relationships and importance as rock-forming minerals." There are some errors in this portion of the book and many irregularities in the headings of the paragraphs. Many chemical formulas are omitted where they might serve a useful purpose. This is particularly true in the case of the silicates, for which no composition formulas are given. In a few cases not even is the composition referred to. There is an unfortunate spacing of paragraphs, that undoubtedly will cause confusion. After the heading "Feldspathoid Group" there is no spacing to indicate that this group does not include all the minerals following it to the end of the book.

These faults, and others like them which might be mentioned, may seem very slight and trivial. As a matter of fact, however, they are serious in a text-book for beginners, since, though they may not teach error, they certainly lead to misconceptions on the part of the students. They may easily be corrected in a revision; and a revised edition, in which these corrections are made, would prove a very satisfactory text-book.

The second part of the volume is devoted to the common rocks. It is so brief as to be of little value. The omission of a number of the rock names mentioned would not have injured the book in the least. Peperino, talus, detritus, eurite, ophiolite, itacolumite, and

hydromica schists occupy the student's attention when he might better be learning something more about gabbro than that it is a "coarse diabase." The use of "syenitic" as an adjective synonymous with hornblendic is no longer to be tolerated in an elementary text-book, in spite of "its wide popular use in this sense in this country." This wrong usage of the word will never be done away with so long as it is taught in the text-books.

There are some inconsistencies in the classification, but they are not mischievous. There are also several statements concerning the composition and origin of a few rocks that will not bear close scrutiny.

Since there are no very elementary text-books dealing with rocks published in English, the present volume has a place to fill. It is a welcome aspirant for the honor of initiating beginners into rock study. It would have been more welcome, however, had it left some of its useless baggage behind. We hope Professor Tillman will revise the entire book, as there are many good points about it. In its scope it certainly "fills a want." The volume contains 38 crystallographic figures but otherwise is not illustrated. W. S. B.

The Differentiation at Magnet Cove. — Washington[1] has made new analyses of some of the Magnet Cove plutonic rocks that lead to interesting conclusions. He finds that many of the earlier analyses are lacking in accuracy. The new analyses result in a change in the former classification of some of the rocks and seem to render necessary a few new rock names. From the analyses he calculates the composition of some of the important types to be as in the table on opposite page.

The covite was formerly regarded as a shonkinite. Its qualitative composition is close to that of theralite. The latter, however, contains a large quantity of nepheline, while the former contains a comparatively small quantity. On the other hand, shonkinite is melanocratic, while covite is mesocratic (that is, it contains about equal quantities of dark and light constituents). According to Rosenbusch's definition covite is a typical shonkinite, but Rosenbusch's shonkinite is an entirely different type from the original shonkinite of Pirsson.

The arkite has been wrongfully designated a syenite. It is most nearly allied to missourite, but it differs from this rock in the same way that covite differs from shonkinite, *i.e.*, it is a leucocratic

[1] *Journ. of Geol.*, vol ix (1901), p. 607.

aggregate of leucite and nepheline, with subordinate dark components. The author defines it as a "holocrystalline, porphyritic, leucocratic combination of leucite (or pseudo-leucite) and nephelite, with pyroxene and garnet." The jacupirangites of Brazil vary from rocks rich in nepheline (true ijolites), through rocks composed predominantly of pyroxene with small and varying amounts of magnetite and nepheline, to types rich in magnetite and with little or no nepheline. The Magnet Cove rock corresponds to the intermediate of the Brazilian types.

	I.	II.	III.	IV.	V.	VI.	VII.
Orthoclase	35.1	28.6	51.8	29.3	3.9		
Albite	39.8	39.0		22.8			
Leucite					36.9		
Nepheline	3.1	6.2	20.3	9.0	25.5	38.7	4.0
Cancrinite			13.1				
Sodalite	1.2						
Nosean		1.2					
Ægirite	5.1	6.9	5.7	4.5	8.4	4.6	
Hornblende	11.0			18.8	Augite	6.9	15.0
Diopside			8.6	9.0	10.8	31.3	64.0
Biotite		7.9					5.0
Apatite	.5			1.0		3.0	
Sphene		2.7	.5	3.1			
Magnetite				2.5			8.7
Extra Al_2O_3	4.2		Garnet		14.5	15.3	

I. Pulaskite, from Fourche Mt., Arkansas.
II. Pulaskite (foyaite), Braddock's Quarry, Fourche Mt.
III. Foyaite, Diamond Jo Quarry, Magnet Cove.
IV. Covite, near schoolhouse, Magnet Cove.
V. Arkite (leucite-porphyry), near Diamond Jo Quarry.
VI. Ijolite, near Dr. Thornton's, Magnet Cove.
VII. Jacupirangite, near Baptist church, Magnet Cove.

In a second[1] article the author discusses the chemical relationships of the rocks with great fullness. He represents the variations in their composition by diagrams and with the aid of these calculates the composition of the magma which gave them birth by methods that are somewhat novel. The peculiar differentiation of the mass is thought to be due to its small size. The process was probably a "sort of fractional crystallization, the magma being regarded as a solution, so that, in accordance with the laws of cooling solutions, the solvent (the portion in excess) crystallizes out first around the borders on

[1] *Journ. of Geol.*, vol. ix (1901), p. 645.

cooling of the mass." The original body of magma was leucocratic, so that the alumina and alkalies with silica enough for the formation of feldspar and feldspathoids, crystallized first, and hence in the periphery of the mass.

Densities of Liquid and Solid Rock Magmas. — In view of the fact that a recently proposed theory of volcanic action accounts for the eruption of lava as the consequence of the expansion of liquid magma in its passage to the solid state, a paper by Doelter,[1] in which this author discusses the densities of liquid and solid magmas, becomes of great interest. By means of a series of experiments, in the course of which fragments of known density were allowed to float or sink in molten magmas, Doelter obtained a series of results which are embodied in the following table, the figures indicating specific gravities:

	NATURAL SUBSTANCE.	MOLTEN.	GLASSY.	CRYSTALLINE.
Melanite. . . .	3.75	3.55–3.6	3.55–3.6	3.65–3.7
Augite	3.3	2.92	2.92–2.95	3.2 –3.25
Limburgite . . .	2.83	2.55–2.57	2.55–2.57	2.75–2.78
Lava (Ætna) . .	2.83	2.58–2.74	2.71–2.75	2.81–2.83
Lava (Vesuvius) .	2.84	2.68–2.74	2.69–2.75	2.77–2.81
Nephelinite. . .	2.74	2.70–2.75	2.686	2.72–2.75
Leucitite. . . .	2.83	2.60–2.68	2.68–2.72	2.75–2.79

The Laccolite of Shefford Mountain.[2] — Shefford Mountain is the easternmost of the series of nine hills of igneous material that rise above the St. Lawrence valley in the neighborhood of Montreal. It is thought by Dresser to be an old laccolite in Lower Cambrian and Trenton sediments. Its material consists of essexite, nordmarkite, and pulaskite, the first two of which possess almost the typical character of these rocks. Associated with these are dark-colored dykes of a camptonitic type, and others of a theralitic type, and light-colored ones of trachyte and bostonite. The latter are the younger. All the rocks are thought to be differentiated products of a single magma. The primary magma, according to this view, had nearly the composition of pulaskite. Excluding the dykes the first differentiate was the basic essexite, the second was the acid nordmarkite, and the third the intermediate pulaskite. The analyses of the essexite (I),

[1] *Neues Jahrb. of Univ.*, etc., Bd. ii (1901), p. 141.

[2] *Amer. Geologist*, vol. xxvii (Oct., 1901), p. 205.

the nordmarkite (II), the pulaskite (III), and the mean between the first two (IV) follow:

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	BaO	MgO	K_2O	Na_2O	P_2O_5	CO_2	SO_3	Cl	H_2O	Total
53.15	1.52	17.64	3.10	4.65	.46	5.66	.13	2.94	3.10	5.00	.65	.39	.28	.07	1.10	= 99.86
65.43	.16	16.96	1.55	1.53	.40	1.36		.22	5.36	5.95	.02		.96	.04	.82	= 99.84
59.96	.66	19.12	1.85	1.73	.49	2.24	.12	.65	4.91	6.98	.14		.08	.14	1.10	=100.17
59.29	.84	17.30	2.32	3.09	.43	3.51	.07	1.58	4.23	5.47	.34	.20	.17	.06	.96	= 99.85

PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

AGLE, W. C. Eastern Peru and Bolivia. Seattle, Wash., Homer M. Hill Publishing Company, 1902. 45 pp. 50 cents. — DAME, L. L., and BROOKS, H. Hand-Book of the Trees of New England. Boston, Ginn & Company. 8vo, xv + 196 pp., 87 pls. $1.35. — FABRE, J. H. Insect Life. Translated from the French by the author of *Mademoiselle Mori*. New York, The Macmillan Company, 1901. xii + 320 pp., 16 full-page illustrations. — GEGENBAUR, C. Vergleichende Anatomie der Wirbelthiere mit Berücksichtigung der Wirbellosen. Bd. ii. Leipzig, Wilhelm Engelmann. viii + 696 pp., 355 figs. 20 marks; bound, 23 marks. — LEAVITT, R. G. Outlines of Botany for the High School Laboratory and Class-Room. New York, American Book Company, 1901. 272 pp., 384 illustrations. $1.00. — MEIER, W. H. D. Herbarium and Plant Description. Boston, Ginn & Company, 1901. Portfolio and 25 folders. 70 cents. — PACKARD, A. S. Lamarck, his Life and Work. New York, Longmans, Green & Co., 1901. 8vo, xiii + 451 pp., 10 pls. — PRATT, H. S. A Course in Invertebrate Zoology. Boston, Ginn & Company. xii + 210 pp. $1.35.

BRIGHAM, A. A. A Modern Dairy Barn. *Bull. Rhode Island Agr. Exp. Sta.*, No. 80. Pp. 17–107, numerous illustrations. — COVILLE, F. V. Ribes aurum and ribes lentum. *Proc. Biol. Soc., Washington.* Vol. xv, pp. 23–29. — DIXON, R. B. Basketry Designs of the Indians of Northern California. *Bull. Am. Mus. Nat. Hist.* Vol. xvii, pt. i, pp. 1–32. — ECKEL, E. C. The Formation as the Basis for Geological Mapping. *Journ. of Geol.* Vol. ix, pp. 708–717. — EIGENMANN, C. H., and KENNEDY, C. Unilateral Coloration with Bilateral Effect. *Science*, N.S. Vol. xiii, pp. 828–830. — EIGENMANN, C. H., and NORRIS, A. A. Bergiaria. *Comunicaciones del Museo Nacional de Buenos Aires.* Tome i, No. 8, p. 272. — EMBODY, G. C. Birds of Madison County, New York. *Bull. Dept. Geol. and Nat. Hist., Colgate University.* — FOSTER, L., and FAIRFIELD, W. H. Experiments in Wheat Culture. *Bull. Univ. of Wyoming Exp. Sta.*, No. 48. — HALL, W. L. Tree Planting on Rural School Grounds. *Farmers' Bull., U.S. Dept. Agr.*, No. 134. 38 pp. 1901. — HOWELL, A. H. The Generic Names of North American Skunks. *Proc. Biol. Soc., Washington.* Vol. xv, pp. 1–9. — JORDAN, D. S., and SINDO, M. A Review of the Pediculate Fishes or Anglers of Japan. *Proc. U.S. Nat. Mus.* Vol. xxiv, pp. 361–381. — JORDAN, D. S., and SINDO, M. A Review of the Japanese Species of Surf Fishes, or Embiotocidæ. *Proc. U.S. Nat. Mus.* Vol. xxiv, pp. 353–359. — JORDAN, D. S., and SNYDER, J. O. A Review of the Discobolous Fishes of Japan. *Proc. U.S. Nat. Mus.* Vol. xxiv, pp. 343–351. — KNIGHT, W. C., and SLOSSEN, E. E. Alkali Lakes and Deposits. *Bull. Univ. of Wyoming Exp. Sta.*, No. 49. — MEARNS, E. A. Description of a New Swallow from the Western United States. *Proc. Biol. Soc., Washington.* Vol. xv, pp. 31–32. — MERRIAM, C. H. Twenty New Pocket Mice (Heteromys and Liomys) from Mexico. *Proc. Biol. Soc.,*

Washington. Vol. xv, pp. 41–50. — MILLER, G. S., JR. The Large Yellow Pond Lilies of the Northeastern United States. *Proc. Biol. Soc., Washington.* Vol. xv, pp. 11–13. — MILLER, G. S., JR. A New Pig from Sumatra. *Proc. Biol. Soc., Washington.* Vol. xv, pp. 51–52. — NEEDHAM, J. G., and HART, C. A. The Dragonflies of Illinois. Pt. i, Petaluridæ, Æschnidæ, and Goniphidæ. *Bull. Ill. State Lab. of Nat. Hist.* Vol. vi, art. i. September, 1901. — OBERHOLSER, H. C. Catalogue of a Collection of Humming Birds from Ecuador and Colombia. *Proc. U. S. Nat. Mus.* Vol. xxiv, pp. 309–342. — PALMER, W., and RILEY, J. H. Descriptions of Three New Birds from Cuba and the Bahamas. *Proc. Biol. Soc., Washington.* Vol. xv, pp. 33–34. — PEARSON, R. A. Market Milk: A Plan for its Improvement. *Seventeenth Annual Report of the Bureau of Animal Industry* (1900). Pp. 158–193, Pls. XXXIII–XLII. — PINCHOT, G. Report of the Forester for 1901. From *Annual Reports, Dept. of Agr.* Washington, 1901. — POLLARD, C. L. New American Species of Chamæcrista. *Proc. Biol. Soc., Washington.* Vol. xv, pp. 19–21. — SCHANS, W. Descriptions of New American Butterflies. *Proc. U. S. Nat. Mus.* Vol. xxiv, pp. 383–460. — SHUFELDT, R. W. Osteology of the Flamingoes. *Annals of the Carnegie Museum.* Vol. i, pp. 295–324. 1901. — SILLOWAY, P. M. Summer Birds of Flathead Lake. *Bull. Univ. of Montana,* No. 3. 83 pp., 16 pls. — SILLOWAY, P. M. Summer Birds of Flathead Lake. *Bull. Univ. of Montana.* Biological Series No. 1. 1901. — STANTON, T. W. Chondrodonta, a New Genus of Ostreiform Mollusks from the Cretaceans, with Descriptions of the Genotype and a New Species. *Proc. U. S. Nat. Mus.* Vol. xxiv, pp. 301–307, Pls. XXV–XXVI. — STEARNS, R. E. C. The Fossil Fresh-Water Shells of the Colorado Desert: their Distribution, Environment, and Variation. *Proc. U. S. Nat. Mus.* Vol. xxiv, pp. 271–299, Pls. XIX–XXIV. — STEJNEGER, L. A New Opisthoglyph Snake from Formosa. *Proc. Biol. Soc., Washington.* Vol. xv, pp. 15–17.

Anales del Museo Nacional de Montevideo. Tome iv, Ent. 22. 1901. — Dept. of Agriculture, Cape of Good Hope. *Annual Report of the Geological Commission,* 1898. Cape Town, Government Printers, 1900. 110 pp. Ditto for 1899, 97 pp. — *Bulletin of the Johns Hopkins Hospital.* Vol. xii, No. 129; vol. xiii, Nos. 130–132. — *Bulletin of the Southern California Academy of Sciences.* Vol. i, No. 1. — *Contributions from the Botanical Laboratory of the University of Pennsylvania.* Vol. ii, No. 2. — *Gakuto.* January, 1902. — *Journal of the Cincinnati Society of Natural History.* Vol. xx, No. 2. — *Journal of Geography.* Vol. i, No. 1. — *Journal of Geology.* Vol. ix, No. 8. — *Mois Scientifique.* 4e Année, No. 1. — *New York University Bi-weekly Bulletin.* Vol. ii, No. 1. — *Proceedings of the Natural Science Association of Staten Island.* Vol. viii, Nos. 10, 11. — *Proceedings Washington Academy of Sciences.* Vol. iii. Contents and Index. — *Report of the Commissioner of the United States Commission of Fish and Fisheries for the Year ending June 30, 1901.* 170 pp. Washington, 1902. — *Revista Chilena de Historia Natural.* Año v, No. 10. October, 1901. — *Revista de Ciencias.* Año ii, No. 1. — *Studi Sassaresi,* pubblicati per cura di alcuni professori della Università di Sassari. Anno i, sez. ii, fasc. 2. December, 1901. — *Tijdschrift der Nederlandsche Dierkundige Vereeniging.* Ser. 2, vol. vii, pt. ii.

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